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Oxyacetylene Pressure Welding of Railroad Rails*

By Lem Adams†

OXYACETYLENE pressure welding is similar in principle to forge welding and electric resistance welding. However, pressure welding is unique in that the bond is formed, without oxide formation, by diffusion and recrystallization at a temperature below the melting point of the materials being joined. The process has been found highly efficient for the butt welding of parts having a uniform cross section. It has been successfully used on oil field tool joints, drill stems, pipe, bars of various shapes and other similar material. One of its most successful and widespread applications, however, because of its efficiency, economy and adaptability to the needs of the industry, is the pressure welding of railroad rails. Introduced to the railroad field in 1938, the method and the machine for doing this work have been in almost constant use since that time and the number and variety of installations of pressure butt-welded rail is growing every day.

Description of the Process

Briefly, the Oxweld automatic process for pressure butt welding of railroad rails consists of bringing the properly prepared ends of two rails together in a suitable, sturdy machine, clamping them in accurate alignment, compressing the ends together with continuously applied hydraulic pressure, while a series of oxyacetylene welding flames are applied completely around the rail ends at the point of juncture. This heat is applied continuously until the metal of the rails reaches the plastic state. When this point in the welding cycle is reached, the weld is completed. Thus the joining is not a fusion weld but a weld in which the action takes place while the metal is, metallurgically speaking, in the solid state.

A portion of the excess metal at the weld, which has become upset during the welding process, is then removed and the weld zone is reheated to above the critical temperature and allowed to cool in a normalizing operation which refines the grain of the metal.

To enlarge and give complete details on the procedure for the butt welding of rails by this process, the various steps will be taken up in order: the preparation and supplying of materials and rail; the welding procedure; the trimming, normalizing and grinding of the welds; a description of a few of the installations of long welded rails; data on tests of welds made by this process; and the results which may be expected through taking advantage of its many features and economies.

* Presented at the Annual Meeting, A. W. S., Philadelphia, Pa., Oct. 20 to 24, 1941.

† Vice-President The Oxweld Railroad Service Company, Chicago, Ill.

Transporting and Setting Up the Equipment

The equipment used on most of the operations of welding rails by the pressure method includes a welding machine and a normalizing unit, both sizable pieces of machinery, and also the necessary trimming mechanism, oxyacetylene cutting blowpipe, manifolds for oxygen and acetylene cylinders, power winch, portable grinding machines and other small tools and attachments. All this equipment is carried from job to job in an end-door boxcar specially arranged for the efficient and speedy set-up necessary for getting this work under way.

Preparatory to the rail-welding program it is necessary for the railroad to assign a convenient yard track or siding for the welding work. The track must be long enough to accommodate the number of cars needed for the job, as follows: one or two flatcars to hold the rails to be fed into the machine; from six to ten flatcars to hold the trimming, normalizing and grinding operations; and a sufficient number of flatcars to hold the full lengths of the finished strings of welded rail. The boxcar in which the welding machine is mounted must also, of course, be accommodated. On some past jobs the longest strings of welded rails were 40 rail lengths, 1560 ft. These required 30 flatcars in a row and a straight track long enough to hold this string of cars.

Arrangement of the Equipment

The various operations are laid out in a continuous production line. The rails to be fed into the welding machine are stacked on skids on a flatcar ahead of the welding-machine boxcar. Next comes the welding machine itself, contained in the boxcar. Located after the welding car is a flatcar containing the trimming and normalizing equipment, and on another flatcar is the grinding equipment, usually two portable grinding machines. The trimming and normalizing and grinding

Fig. 1—The Welder Car Showing Oxygen and Acetylene Cylinder Supplies and Power Unit

equipment is positioned on the flatcars so that each operation is performed one or two rail lengths away from the work position of the previous operation. A power winch is set up at the outer edge of the flatcar row to pull the welded rail strings out onto the flatcars after each operation is completed. On the flatcars are mounted a sufficient number of rollers and skids so that the continuous rail can be readily pulled from one work position to the next.

The supply of welding gases is piped from groups of cylinders which are manifolded together and set in place outside of the boxcar.

Preparation of the Rails for Welding

Although most of the oxyacetylene pressure butt welding of rail has been done on 112-lb. and 131-lb. rail, any section of rail can be welded by this method provided that correctly designed welding heads and procedures are used.

In order to make a sound and straight weld, it is important that the two rail ends shall be square and shall fit tightly together without any air space in between them. To assure this fit, the rail to be welded is usually supplied with mill-finished ends, so that if any preparation grinding is necessary it is little more than a polishing operation. The steel mills are also ordered to furnish the rail steel without bolt holes so that the full strength of the entire rail can be utilized. In the event that the rails have not been mill-finished, grinding is done on the job with a surface grinding wheel mounted in a special guide. When this is necessary, the rails are usually stacked alongside the work track in crib fashion so that the end of each rail extends out of the stack and can easily be ground and tested for squareness with a try square.

After the mill-finishing or end-grinding, a protective grease coating is put on each rail end to keep it from rusting. The operator of the welding machine removes this coating before welding, using a suitable solvent.

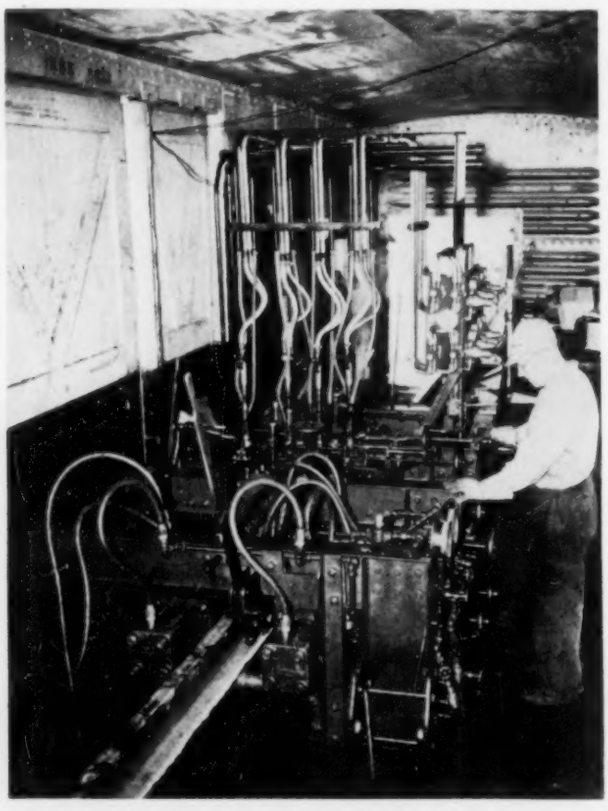

Fig. 2—The Pressure Butt-Welding Machine in Operation

Fig. 3—Pressue Butt-Welded Rail Before Trimming

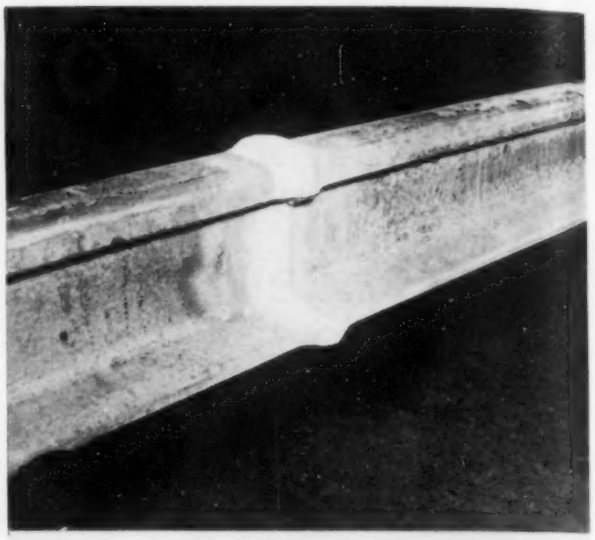

Fig. 4—Trimming Upset Weld Metal with an Oxyacetylene Cutting Blowpipe

The rails to be welded are customarily piled alongside the feeder car which is spotted immediately ahead of the welding car. They are then hoisted onto the feeder car and placed on special skids so that they can be easily pushed into the welding machine.

Operation of the Welding Unit

In performing the welding operation two rails are fed into the welding machine and hydraulically operated clamps formed to the contours of the rail cross section are applied to the sides of each rail end. These clamps grip the sides of the rails and are moved together to force the rail ends against each other. A pressure of approximately 2500 lb. per sq. in. is applied, or about 25,000 lb. on the end of an 112-lb. section rail. Hydraulic pressure for the operation is provided by a small power unit which also operates a pump to circulate cold water through the

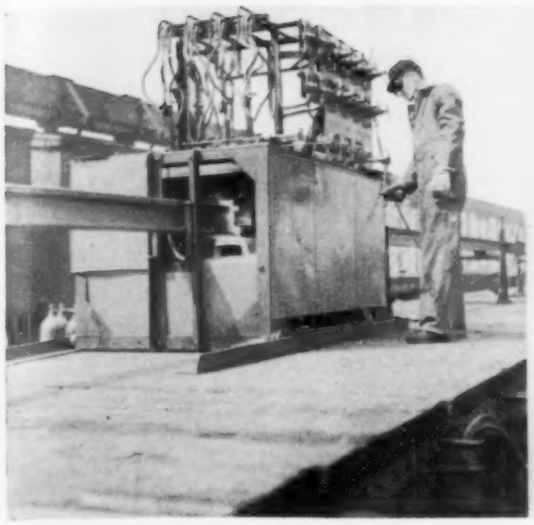

Fig. 5—The Normalizing Unit in Operation

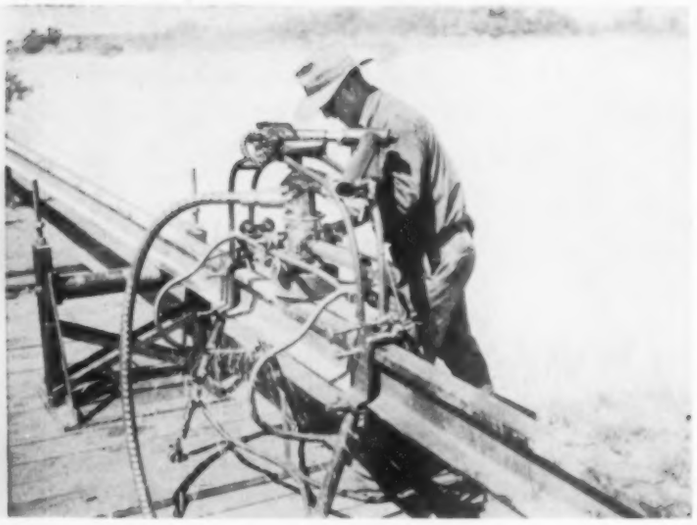

Fig. 6—Grinding the Welds to a Smooth-Riding Surface

welding heads to prevent their overheating. The pressure is applied before the welding flames are lighted and is maintained throughout the welding operation.

Due to the irregularly shaped cross section of a railroad rail, it is necessary to allocate the heat during the welding process to bring all the rail to a welding temperature at the same time without overheating the thinner sections. To accomplish this, four oxyacetylene blowpipes with multiple-flame welding heads are used. To impart an even heat all the way around the cross-sectional contour of the rail ends, one welding head is positioned at the top, one at the bottom, and one on each of the two sides of the rail. Each of these heads contains a number of welding tips which produce flames of different sizes so as to equalize the heating action. Large flames are applied to the ball and to the center of the base; smaller flames are applied on the web and on the flanges of the base.

The flames of the welding heads are lighted, the bottom head first, a few moments later the top head, and then the two side heads. As soon as the heads are lighted, the carriage in which the blowpipes are mounted is automatically moved backward and forward along the rail to prevent the intense heat of the oxyacetylene flames from being applied at any one point of the rail for too long a period. The lateral travel of the heads in this reciprocating motion is approximately 2 inches.

Timing and Upsetting Show When Weld Is Completed

It takes about 8 minutes to make a weld in 112-lb. section rail. This is the actual welding-cycle time only, considerable additional time being taken up in moving the welded rail out, positioning a new rail in the machine and getting everything ready for the next weld. Including this setting-up time, it requires an average of 20 minutes for the complete operation, or an average of about three welds per hour. Twenty-five welds in an 8-hour working day is felt to be a good average, although as many as 32 welds have been made in this time when conditions were favorable and no delays were encountered.

As the heating time draws to an end and as the metal reaches the plastic stage, the continuously applied pressure causes it to upset slowly at the joint line so that when the weld is completed there is a ridge ranging from $^1/_4$ in. to $^1/_2$ in. in height extending around the entire outline of the rail cross section at the point of welding. This ridge is formed of extra rail metal upset by the pressure.

A scale is provided on the machine to give a measure of the shortening of the rails due to this upsetting action. The amount of shortening is the determining factor in the completion of the weld. When the scale indicates that each rail has been shortened approximately $^3/_8$ in. or the total shortening of the two rail ends is $^3/_4$ in., the operator knows that the welding has been accomplished. The welding flames are then turned off and the rail allowed to cool for a couple of minutes before being pulled out of the machine to the finishing operations, which start usually 39 ft., or one rail length, away on the first flat-car.

Trimming Off the Upset Metal

In order to finish the rail for service the ridge of metal formed by the welding process must be removed from the top and sides of the ball of the rail and from the sides of the base of the rail. Most of this metal is now cut off with an oxyacetylene cutting blowpipe guided on a small mechanical fixture. Five separate oxyacetylene cuts are made. In trimming, no attempt is made to cut as closely as would be needed for final finishing. This operation is performed simply to reduce the amount of finish-grinding which would otherwise be necessary later. The rail is then moved forward another rail length (39 ft.) to the normalizing unit.

The Normalizing Procedure

Between the time it leaves the welding machine and arrives at the normalizing unit the rail has cooled down sufficiently below the critical temperature to allow the grain structure to form. The normalizing cycle is now applied to refine this grain. In the normalizing operation no pressure is used. Four oxyacetylene heating heads similar in shape to those used in the welding operation are applied and oscillated over the welding zone. This area is uniformly reheated to a temperature slightly above the critical point and then allowed to cool in the atmosphere.

The trimming and the normalizing operations together take a little less than 8 minutes or about the same time

as is necessary for the making of a weld. Most jobs are accordingly set up so that one operator does both the trimming and the normalizing, thus keeping the production line constantly progressing.

Finishing the Rail Welds by Grinding

By means of the power winch, the welded string of rails is pulled out onto the flatcars to the position for the final operation—grinding the weld area to produce a smooth-running surface. Portable grinders are used to smooth off the top surface and the sides of the ball of the rail, and the sides of the base.

Laying Pressure-Welded Rails

After the required number of long strings of welded rails have been made up, the flatcars are pulled out of the yard track to the location where the rails are to be laid. No difficulty is encountered in transporting the rails around curves or through turnouts since the weight of the rail steel builds up enough normal friction to hold the rails fairly stable on the skids and they bend naturally as the train moves around curves.

For unloading long strings of welded rail, two methods are in general use. Usually, particularly with the shorter strings of welded rails, it has been found satisfactory to pull the rails off the cars by using a locomotive as the tractive agent. When the welded strings are of from 25 to 40 rail lengths, one end of the string can be anchored to the ground and the flatcars pulled out from under it, letting the rail skid into approximate position on the ties. The welded rails are then barred into position and fastened to the ties in the usual manner.

Recent articles in the technical press by civil engineers and railroad engineers have definitely shown that expansion and contraction of long lengths of welded rail is an engineering problem which can be easily solved by the application of correct railroad engineering practices.

An interesting sidelight on this subject came in a discussion of the matter about a year ago with one of the prominent railroad engineers of the country. He remarked at that time that there seemed to be an impression among railroad men that there was something new about the findings that there was little, if any, expansion or contraction in correctly laid continuous welded rails.

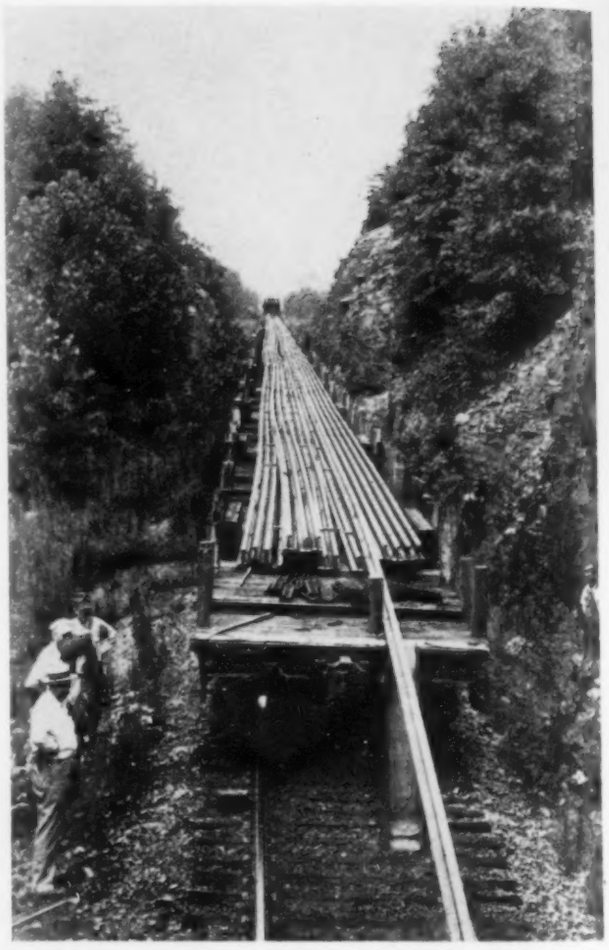

Fig. 9—Pulling Off 1050-Ft. Lengths of Pressure-Welded Rail at the Portal of a Tunnel

He reached back from his desk and pulled an old copy of "Trautwine" out of his bookcase and opened to a paragraph reading as follows:

"It is a remarkable fact not satisfactorily accounted for that when lengths of from one hundred yards to some miles of rails have been perfectly welded (or riveted tightly together) and spiked to the ties as usual, no

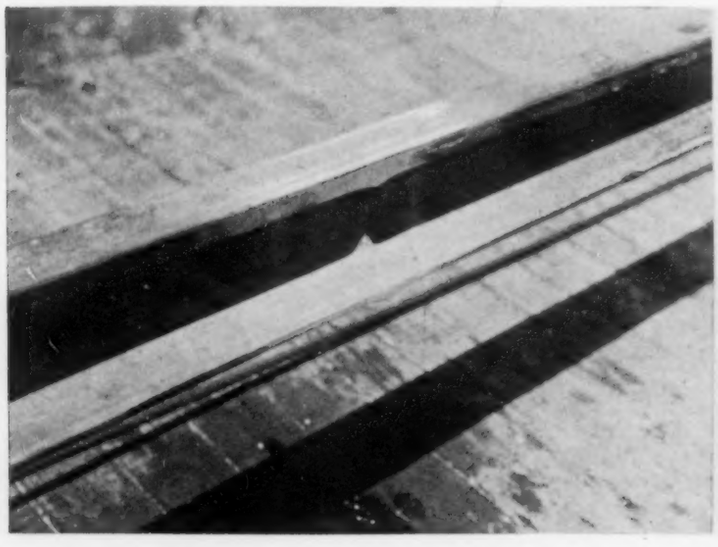

Fig. 7—Finish-Ground Pressure Weld in Rail

Fig. 8—Welded Rail Strings on Flatcars

Fig. 10—Lining Pressure-Welded Rail Into Position Along the Right of Way Prior to Pulling, so as to Avoid Damage to Ties. Note the Relatively Small Crew Necessary for Handling the Rail

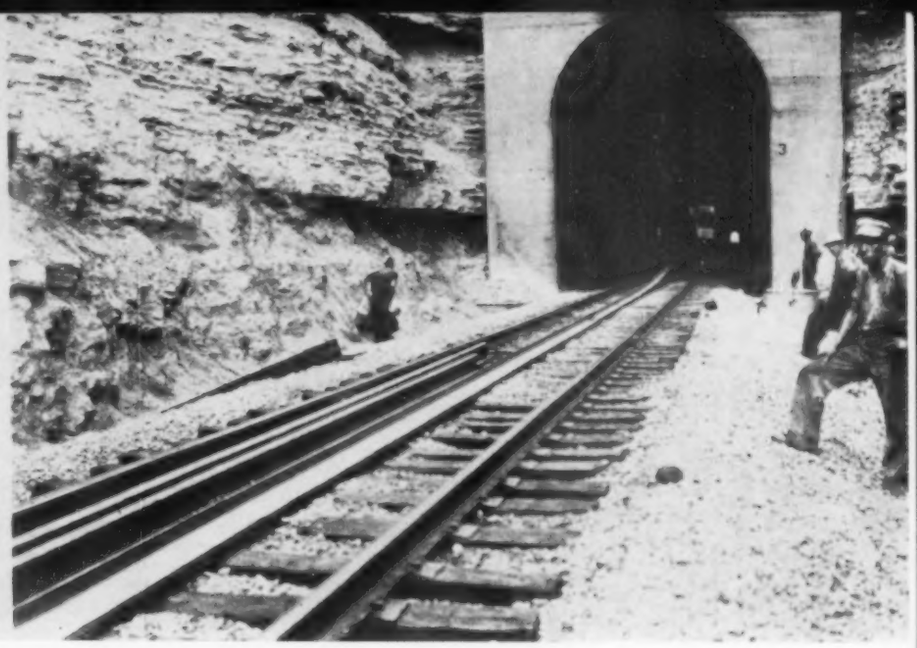

Fig. 11—A Small Crane Pulling Pressure-Welded Rail Into a Tunnel

elongation or contraction by heat or cold could be detected."

This copy of "Trautwine" was published in 1874. This story illustrates that recent developments in connection with installing continuous welded rails are confirmation of railroad engineering principles outlined in a standard publication used by railroad engineers over sixty years ago.

This does not mean, however, that the matter of securely fastening the rails to the ties can be in any way neglected. It is obvious that, in order to prevent lengthwise expansion in long stretches of welded rails, the rail must be adequately anchored. This has not been found a difficult problem, however, and has been solved in a number of different ways, the construction ranging from installations using various types or rigid patented fastenings all the way to track on which an adequate number of standard rail anchors were used in conjunction with double-shoulder tie plates.

Field and Laboratory Tests and Their Results

In the actual preparation, welding and laying of continuous lengths of pressure butt-welded rail, the only tests made are by regular straightedge application to obtain assurance that the welds are accurate and straight and that grinding has been done correctly and accurately on the prepared rail ends and over the weld area in finishing.

There have been, however, thorough and extensive laboratory tests of oxyacetylene pressure-welded rails and all the results have been favorable. As you may know, the Rail Committee of the American Railway Engineering Association has since 1937 been carrying on an investigation of continuous welded rail with the cooperation of the Engineering Experiment Station of the University of Illinois under the direction of Professor H. F. Moore. Many tests have been made by this group and two reports have been offered at A. R. E. A. Conventions in 1939 and 1940 to keep the railroad industry up to date on the progress of the work. The tests included metallographic studies of the welded joints and rail metal, mechanical tests of sections cut from the rail metal at the weld, tests of full-section welded specimens under repeated wheel loads, and drop and bend tests of full-section welded rail specimens.

In the physical tests, the welds made in 112-lb. and 131-lb. section rail by pressure welding showed remarkably high qualities. For example, the average tensile strength of samples taken from the weld metal of pressure-welded rail was 130,833 lb. per sq. in.—within 2% of the strength of the unwelded rail metal, 133,000 lb. per sq. in. Some of the individual samples tested showed a tensile strength even greater than that of the rail.

The results of ductility tests, endurance-limit tests, reduction-of-area tests and tension-impact tests demonstrated that welds made by this method were equal or superior to the welds of any other process tested in this series of investigations.

Rolling-Load Tests

In the rolling-load tests, full-sized specimens of 112-lb. section rail were tested under a wheel load of 55,000 lb. and 131-lb. section welded rail specimens under a wheel load of 75,000 lb. These oxyacetylene pressure-welded specimens withstood, without failure of any of these specimens, over two million cycles of load before the test was considered concluded.

In the bend tests of welded 131-lb. rail specimens, the maximum load before fracture on oxyacetylene pressure-welded specimens was 320,900 lb., which was 5000 lb. greater than the load withstood by the next strongest welded specimen, and which compared favorably with 300,000 lb. which was the maximum load before fracture on original rail which had not been welded.

Still another comparison was furnished by the A. R. E. A. rolling-load tests when standard joint-bar connections were tested to compare them with the results obtained with the welded specimens, and against original rail. The results show that conventional joint-bar assemblies could be expected to have only about two-thirds the strength of the original rail or of rails welded by oxyacetylene pressure welding.

Field tests of an actual stretch of various types of welded rails in track are contemplated as a future work of the joint investigation committee.

Installations in Which Pressure-Welded Rail Has Been Used

Pressure butt-welded rail has many uses. It is particularly suited for use in tunnels, through station platforms, over bridges, through road crossings, paved streets, for turnouts and other places where the rail is either covered

or difficult to get to for maintenance of joints. It has also been considerably used for open track.

Road Crossings.—It has been used extensively for road crossings, as a means of avoiding the excessive maintenance usually needed at these locations and to avoid early breakdown of pavement due to low and loose joints.

The usual procedure is to weld the steel rails to be used for a number of road crossings at a central welding point. These strings may be two or three or sometimes as many as six rail lengths, the latter for locations where the crossing of the road is made at an extremely flat angle. When all the strings of welded rail called for in the plans are welded they are shipped on flatcars to the various points on the system where they are to be laid. The results of this organized procedure have been found so successful that several large railroads have decided to standardize on oxyacetylene pressure welding for all their new road-crossing rail.

Turnouts.—Pressure welding is also recommended for the lead rail on turnouts.

Station Platforms.—Similar success has been had with pressure-welded rail laid through station platforms and with track running through city streets and similar paved locations. The rail can be welded on a convenient spur track and then pulled into place and set in the pavement.

Bridges.—Pressure-welded rail, by reducing impact, has also proved its value on bridges. Bridge engineers estimate that in various stages of wear in the rail the impact will be reduced by from 15 to 50%. Another highly important feature of this type of track is the elimination of noise and vibration, particularly where the bridge locations are in thickly settled communities.

Tunnels.—Perhaps the greatest advantage in the welding of rail for use in tunnels lies in the elimination of joint bars, bonds and other connections which are usually the localized areas where corrosion sets in. Over a mile of oxyacetylene pressure-welded rail was laid this summer in a tunnel in southern Illinois and it is felt that this piece of track will have a long life with lowered maintenance. The many advantages of oxyacetylene pressure butt welding of rails can also be used by subway traction companies for their underground track.

Open Track.—Continuous welded open high-speed track has not been in general use long enough for much to be said on this particular use of pressure butt-welded rail. There have been, however, a number of successful installations on main-line service and particularly on heavy traffic lines. The welded rail has proved to be entirely satisfactory for the extremely heavy wheel loads and traffic which some of this track has had to undergo. In the use of pressure-welded rail for open track, careful consideration must be given by the railroad engineer to the subject of track fastenings. The selection of a suitable type of fastening is essential to the success of the installation.

There is one major point which should be carefully considered in any discussion of the future use of continuous welded rails. With increased speeds that impose the need of a greater degree of refinement in rail surface, it is obvious that as many rail joints should be eliminated as is economically possible to insure a continuance of the even surface and to provide safe, comfortable, and speedy transportation for passengers and freight.

National Acceptance

The acceptance that the oxyacetylene pressure-welding process has received from railroad engineers and officials has been country-wide. Rails welded by this method have been laid in California and in New England as well as at other points throughout the country. They are in track as far north as Minnesota and as far south as Arizona and Texas so that the welded rails have been subjected to a full variety of weather conditions and temperature changes. On several railroads the process is being used exclusively wherever welding is to be used on new rail.

Advantages of Pressure Butt Welding of Rail

The advantages of oxyacetylene pressure butt welding for railroad rail are many and can be briefly summarized as follows:

1. Elimination of Maintenance.—Joint maintenance is entirely eliminated. With continuous welded rail there is no necessity for shimming, joint-bar or bolt replacement, bond replacement, building up rail ends by welding or other operations which are necessary to maintain rail joined by conventional methods. Since there is no batter, wear on joint ties is also substantially reduced.

2. Low Cost.—For a number of reasons the cost of oxyacetylene pressure welding is considerably less than previously used methods of welding continuous welded rail. It requires a small crew (only about 10 men) to perform the entire welding operation. The labor required for most of the operations involved in making the weld can be unskilled, and hence the labor cost is low. No joint bars or signal bonds are needed on welds made by this method and as a result the cost of bars, bolts, bonds and bonding can be deducted in estimating the cost of proposed welding jobs. With the new portable unit costs will be even lower than now.

3. Essential Equipment Furnished and Serviced.—The essential equipment is the welding machine, the normalizing unit, the power winch to pull the welded

Fig. 12—Oxyacetylene Pressure Butt-Welded Rail in Open Track

rails out of the machine, the necessary flexible-shaft grinders for finishing the welds, standard ball-bearing rollers for holding the rail strings after they have been pulled out of the machine, oxyacetylene equipment for cutting off the excess metal on the ball and base of the rail, and the manifolds for the cylinders of oxygen and acetylene. The equipment is kept in condition by Railroad Service instructors and engineers.

4. *Simplicity of Equipment.*—The equipment, extensive as the list may seem, can all be carried in a single boxcar. No locomotives or heavy equipment is tied up during the welding work. The only additional equipment required is a side track and a sufficient number of flatcars for the job, furnished by the railroad.

5. *No Human Element.*—In this process the rails are joined by a purely mechanical means employing heat and pressure, and the weld is made without fusion. The mechanization of the process and the establishment of proved indications for a high-quality weld do away entirely with the personal element and assure uniformly sound and efficient welds every time.

6. *Quality of the Weld.*—The greatest advantage to the railroads (since they have always been quality-minded) is that laboratory and field tests have proved that butt welds made by the oxyacetylene pressure-welding process are unsurpassed for strength and efficiency, highly suited for use on railroad rail for any type of service.

These economies and advantages are of great value to the railroad maintenance-of-way engineer and of great significance to the railroad officials concerned with the specification or purchase of this type of welding service for the railroad. There are, in addition to these purely technical and financial advantages, certain features of a more or less general interest which strikingly emphasize the desirability of specifying continuous, pressure butt-welded rail. These include the elimination of vibration in bridge structures, the decrease of noise in bridges and other track, road crossings and other locations, and a smoothness of transportation which adds materially to the comfort of passengers and gives shock-proof transportation to freight and express, thus reducing wear and tear on rolling stock. Last but by no means least is the fact that there is an improved appearance of track that has been welded by this method.

A Survey of Aircraft Resistance Welding Equipment*

By L. P. Wood†

SINCE I acceded to the request of the SOCIETY to present a paper on aircraft welding at this meeting I have seen numerous articles in various trade journals on aircraft resistance welding. All of these papers presented a variety of welding data and described various new methods of resistance welding. I could, in this paper, present various welding data which I have obtained through test and study, but they would probably be no different or better than data already available to the industry. A very fine job on this score is being done by the Resistance Welding Research Committee, and I prefer to wait for their reports because they will be the results of very thorough and intensive research and will be more representative of the industry as a whole.

Conditions in the world today point to one very definite conclusion and that is that the airplane is one of the most important factors in deciding the eventual outcome. For this reason, national defense points attention to the need for airplanes in tremendous quantities. This, in turn, means that high-speed production methods must be thoroughly investigated and applied to the production of aircraft wherever this can be done without sacrificing quality.

Resistance welding, and spot welding in particular, have probably received as great a boost due to the present emergency, as any other means of aircraft fabrication. Spot welding has been used in the fabrication of aircraft for a number of years, but only in the past year or two has it been so much in the limelight.

It is apparent even to a layman that one of the real stumbling blocks in the high-speed production of aircraft exists in the necessity of driving a staggering number of rivets. Quantity of rivets ranges from 50,000 to hundreds of thousands for airplanes of all-metal construction depending on whether they are single place pursuits or multi-engine bombers. Spot welding offers a very attractive alternative.

A great deal of credit must be given to welding machine manufacturers for the development they have made in methods of spot welding in recent years. It has been in a large part due to improved quality of welds resulting from these new methods that spot welding has been so highly successful.

As an introduction to the three new methods of spot welding which I will discuss it is interesting to note that not one of them uses the old conventional A.C. method with vacuum tube control. New developments in welding equipment are aimed at three things: higher quality welds, faster production and decreased power consumption. Due to the high currents necessary to weld alloys used in aircraft, mainly aluminum, the greatest effort has been directed to decreasing power requirements.

The most recently developed method is a three-phase process which uses rectified or unidirectional current for the actual welding. The diagram in Fig. 1 shows the schematic principle by which this method is accomplished. Essentially, it consists of passing the current from the three-phase power supply (*A* in Fig. 2) through a special transformer with one set of the three coils reversed or inverted so as to give a 60-degree spacing between wave forms (*B* in Fig. 2) instead of 120 degrees.

* Presented at the Annual Meeting, A. W. S., Philadelphia, Pa., Oct. 20 to 24, 1941.

† Materials Engineer, Curtiss-Wright Corporation, Airplane Division, Columbus Plant, Columbus, Ohio.

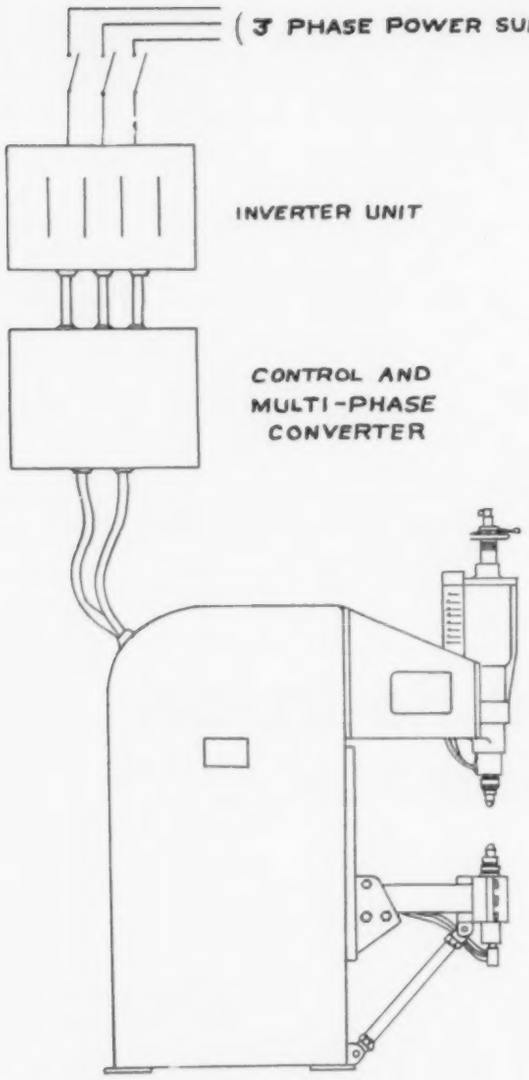

Fig. 1

The resulting current is then passed through a three-phase rectifier, consisting of three ignitron tubes which not only rectify the current but also act as contactors for making and breaking the current. The firing of tubes is controlled by an electronic timing panel. The rectified or converted current (*C* in Fig. 2) then passes through the welding transformer and is amplified in the usual manner. The resulting secondary current or welding current (*D* in Fig. 2) has characteristics which make it more suitable for the welding of aluminum alloys than the conventional A.C. wave form. The current rises to its maximum in less than $^1/_{100}$ second, holds this value for a short period of time and then drops to zero in an extremely short period of time. This is shown in *D* and *E* of Fig. 2.

The operation of the welding sequence from depression of the foot pedal to release of the electrodes from the work is, of course, entirely automatic. This automatic sequencing of operations is accomplished by the timer panel which houses the main ignitron tubes and accessories necessary for controlling them. A wide range of aluminum welding operations is permitted because the weld time can be varied anywhere from a maximum of approximately one (1) cycle down to one-sixth ($^1/_6$) cycle. Such fine control permits welding of very thin sheets up to two pieces each $^1/_8$ in. in thickness.

The mechanical features of the equipment are similar to standard pedestal-type welding equipment. Welding pressures are obtained through a conventional direct air-operated pressure cylinder which is mounted on the upper arm and actuates the upper electrode to move it against the work. Provision is also made for the upper electrode to follow through as the weld is made. The equipment also provides for conventional automatic repeat timing. A double cylinder arrangement is provided to give a forging pressure in addition to a welding pressure.

This welding process has an advantage over the stored energy types in that it does not have to take time for a charging process. Welding power comes almost directly from the line. Speeds up to 100 welds per minute are possible. Speed is practically only limited by the speed with which the operator can move the work between welds. However, this method of supplying welding power results in this type of machine requiring a much larger power supply than stored energy types and approximately one-half that of conventional A.C. machines.

Due to the fairly short time this machine has been on the market and in use, very little actual data have been published concerning the welds produced by the process.

The second newest process offered to the industry for the spot welding of light-weight alloys is the condenser discharge welding or capacitor type stored energy welding.

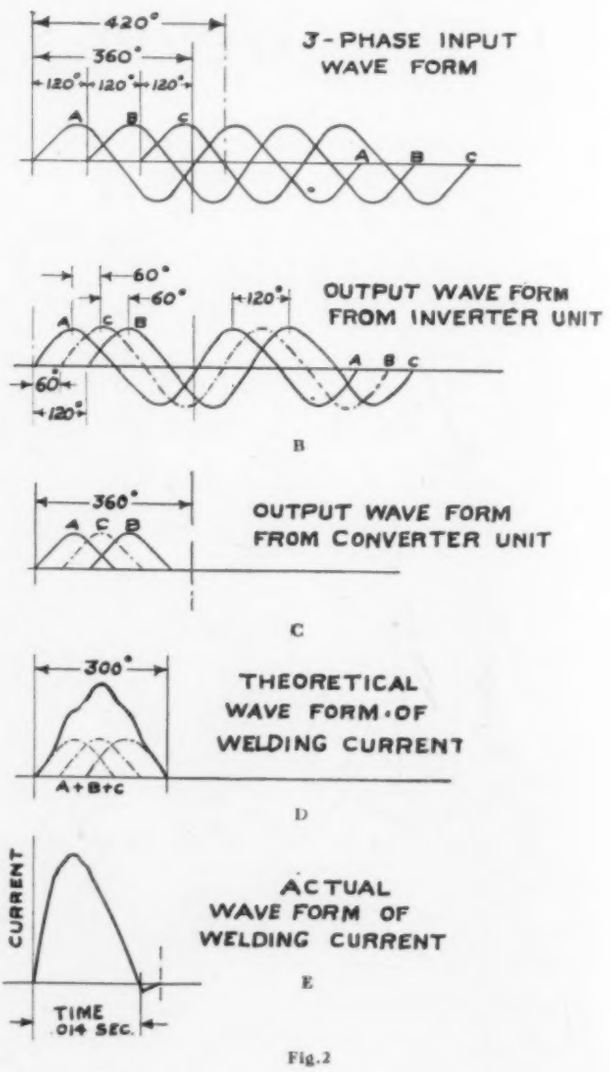

Fig. 2

The capacitor type stored energy method was introduced in Europe in 1938 by a Paris manufacturer, Languepin. Several units were installed in France and other European countries. However, it was not until this type of welder was introduced into this country by American manufacturers that it was more widely adopted and more information was obtained to prove its practicability for use in the production welding of aircraft parts.

This method operates on the stored energy principle. The sequence is completely automatic and the charge and discharge of the stored energy are electronically controlled. A schematic diagram of one manufacturer's welding power circuit is shown in Fig. 3. Briefly, during the time interval between spot welds, the capacitor bank is charged to a preset voltage level and to make the weld is discharged into the welding machine.

Features of this equipment include means to manipulate the wave form of the discharge current by simple, flexible control, using electronic tube switching. Also, particular attention has been paid to designing a lightweight frictionless electrode head to permit "follow-up" of electrode pressure. As in other types of D.C. welders

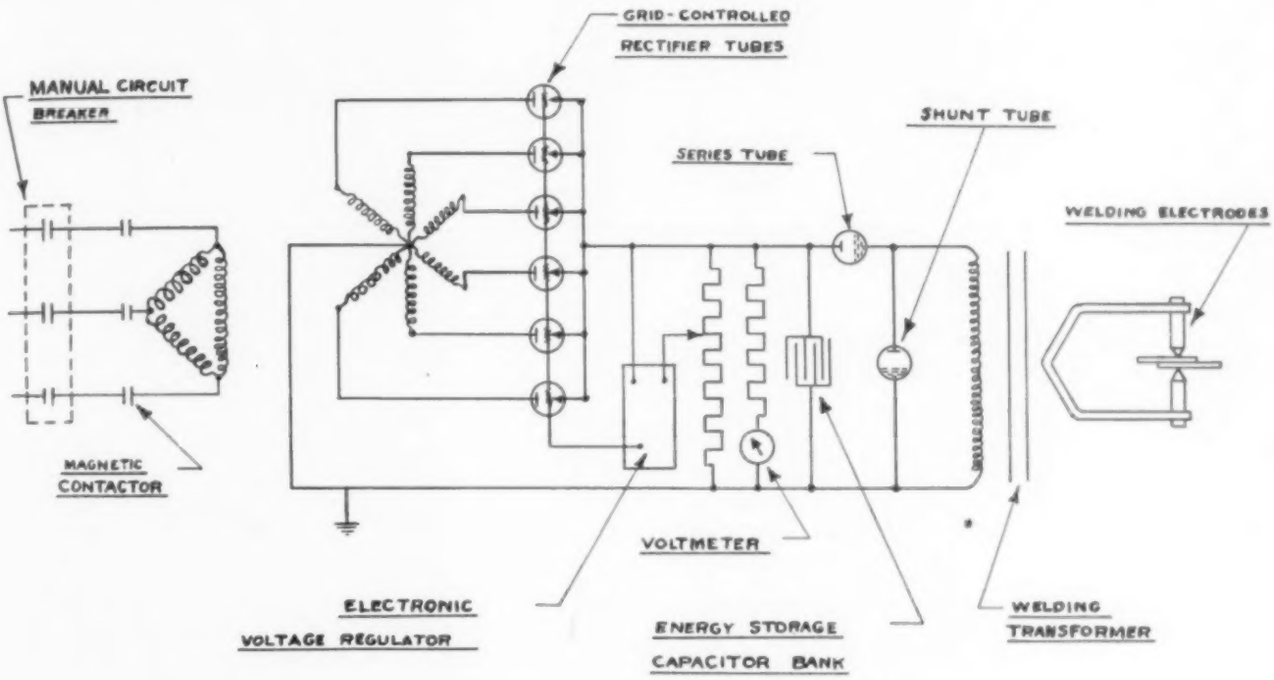

Fig. 3

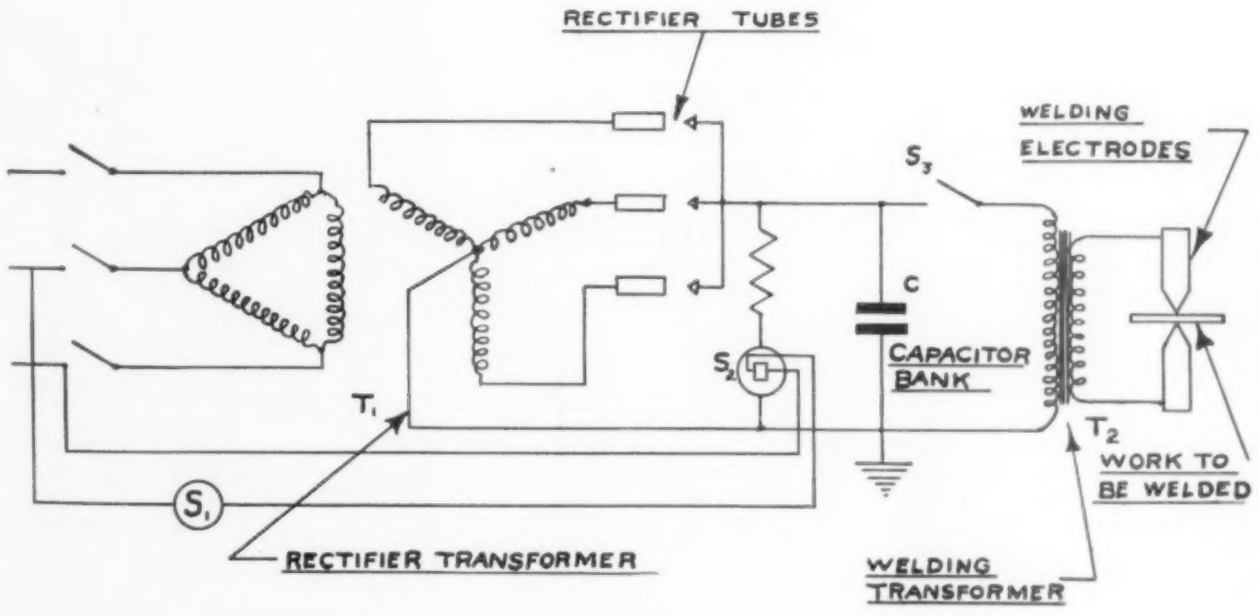

Fig. 4

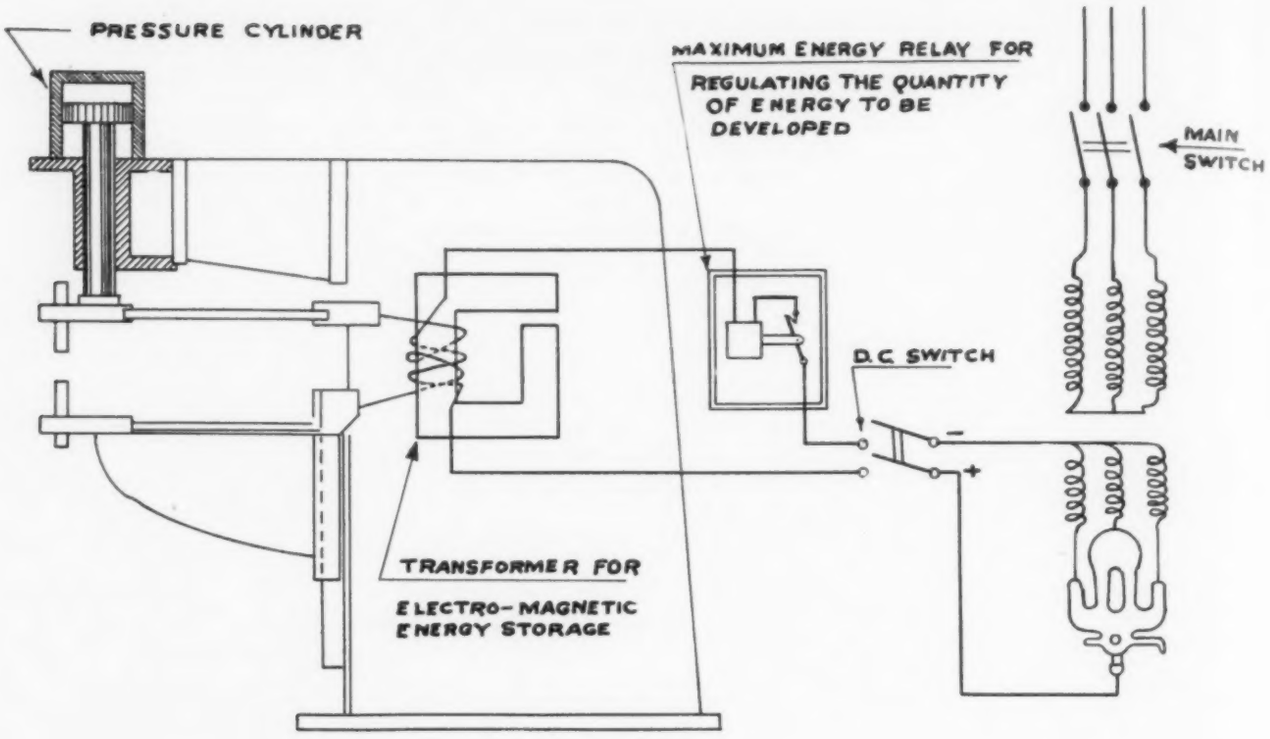

Fig. 5

the kva. demand is a balanced three-phase load of high power factor and the demand required from the power lines is greatly reduced as compared with the single-phase A.C. welders. Assuming an average duty cycle, the kva. demand of balanced three-phase load for a welder operating on stored energy is between $^1/_3$ and $^1/_5$ of the demand required by a single-phase A.C. welder. This figure varies slightly depending on duty cycle and thickness of material being welded.

Welding power is supplied by energy taken from an ordinary single- or three-phase shop supply line. The three-phase power is converted into high voltage D.C. by means of controlled rectifier tubes and is then applied to the capacitor bank where the energy is accumulated over a relatively long period of time, usually several times that required to discharge this energy. After a preset, measured quantity of energy has been accumulated in the capacitor bank, operation of the electronic control tubes causes the capacitor bank to discharge directly into the primary of the welding transformer as a single unidirectional current impulse magnified many times by the transformer to produce the current necessary for making the weld. The discharge is accomplished by firing a series tube which completes the circuit from the capacitor bank to the welding transformer. The energy is locked in the welding transformer by operation of a tube which is shunted across the primary terminals. This permits the induced or welding current to decay along an exponential curve until all energy is dissipated.

Changes in wave shape are accomplished by changing the transformer turn ratio or the value of capacitance. Increasing the turn ratio with voltage and capacitance constant causes a less steep wave front or a more flattened out wave. Increasing the value of the capacitance with voltage and turn ratio constant raises the current peak and causes a more steep rate-of-decline. However, the slope of the wave front (rate-of-rise) remains constant.

Another welder of this type operates on a principle similar to the first one described. A schematic diagram of this welder is shown in Fig. 4. To operate, a switch (*S*1) is closed which supplies three-phase power to the rectifier transformer (*T*1). This power is rectified and charges the capacitor bank (*C*) with D.C. The voltage across the capacitor bank rises until it has reached a sufficient value to operate the coil of a relay (*S*2). The voltage to which the capacitor rises is determined by the setting of this relay. This, in conjunction with the value of capacitance used, accurately determines the amount of energy stored in the capacitor. When this relay operates the power switch (*S*1) opens thereby cutting off the charging current. A contactor (*S*3) between the capacitor and the welding transformer (*T*2) primary is automatically closed, thereby discharging the energy stored in the capacitor through the primary of the welding transformer. This, in turn, induces a flow of current, which is magnified many times, in the secondary of the welding transformer and a weld is made. Since the amount of energy used in making the weld is the energy stored in the capacitance, which can be controlled very accurately, less the fixed losses inherent in the machine, this system provides for welds being made with uniform and accurately measured amounts of energy. This is highly important in the welding of light alloys for aircraft.

More recently a third manufacturer has put a condenser discharge welder on the market. The principle is similar to other condenser discharge machines. The three-phase power supply is rectified into high voltage D.C. which is used to charge the condenser bank. Suitable controls cause the condenser to discharge a unidirectional current impulse through the welding transformer. The wave form of the discharge current can be varied by changing the amount of capacitance, condenser voltage or the welding transformer turn ratio.

The welding head of this machine is actuated by a motor-driven cam which operates an air pressure device. This device is so designed that a variable pressure may

be applied to the work. That is, a high pressure is used to bring the work into intimate contact, pressure is reduced for welding and is then raised again to provide a forging action on the welded metal.

The third of the new types of spot-welding machines presented in this country in recent years is the electromagnetic stored energy process. This is the only one of this type of stored energy welder used in the aircraft industry in this country. The first installations of this type of equipment were made about three years ago.

The background of this welder is quite interesting. The first machine was developed as far back as 1927 and was successfully used by a French aircraft manufacturer in the spot welding of structural aluminum alloy members. Since then a great amount of research and development has been carried on to provide a machine capable of being adopted in a practical and rational manner to the needs of the fast growing aircraft industry. Hundreds of machines were built and put into use in various European factories and in 1938 a definite effort was made to establish business in this country. Today, practically every major American aircraft manufacturer is operating one or more electromagnetic stored energy type of welders. Also, stored energy machines of the electromagnetic or condenser type account for practically all of the installations being made in aircraft plants today for the welding of aluminum alloys.

As stated previously this welder is the only one which operates on the electromagnetic stored energy principle. The fundamental parts of this machine (see Fig. 5) consist of a rectifier which receives three-phase A.C. from the power supply and converts it into D.C.; a transformer for energy storage, which receives the D.C. and stores it over a period of time; a contactor and a maximum current relay interposed between the rectifier and the transformer. The relay serves the purpose of causing the contactor which is a multiple type to open at a preselected value, thus regulating the amount of energy stored in the transformer. Upon interruption of the charging current in the primary winding, the electromagnetic energy stored in the transformer is discharged through the secondary which is connected to the electrodes which are closed prior to the storing of energy.

This machine was the first to incorporate the variable-pressure cycle. This consists of applying a high initial load on the work to establish uniform contact, decreasing the pressure for welding, and raising it again to mechanically work the weld while it is still hot. Also, due to the fact that the electrodes must be closed while energy is being stored, a small negative current flows which serves to slightly preheat the work. This aids in bringing the work into contact and possibly reduces the tendency for the metal adjacent to the weld to develop fine fractures as is sometimes the case when the temperature gradient between this metal and the weld itself is too steep.

Several other features which have recently been incorporated are worth noting. A retractable head can be provided which permits opening the electrodes to approximately four (4) inches for insertion of the work and closing to $^1/_2$-in. gap for welding. This is a feature found previously on other machines. To increase contactor life and shorten the breaking time, the number of contactors used to break the charging current has been increased from four (4) to eight (8). The addition of a short-circuiting contactor decreases the time necessary for the decay of current. This changes the wave form slightly and permits a faster welding cycle. Provision has also been made for connecting another storage reactor in parallel with the main reactor. This cuts the charging time approximately in half without increasing the preheating current. This is possible because the main reactor only has a secondary winding. The two reactors have similar characteristics so that the current rise in each is equal. These improvements have been directed at decreasing the length of the welding cycle without decreasing weld quality. They have increased the welding speed to a point where it is compatible with the maximum speed with which a skilled operator can manually handle the average type of aircraft assembly in a spot welder.

New developments have also been directed at reducing the arcing of the contactors used to interrupt the charging current. This is important because energy delivered to the secondary for making the weld is affected by any energy which may be lost in arcing, and whenever current is interrupted by mechanical contactors there is bound to be a certain amount of arcing. Consequently, if there is a variation in the degree of arcing there will be a variation in the amount of energy delivered for successive welds. Since arcing of mechanical contactors cannot be eliminated entirely the primary object is to reduce it to a minimum and to provide for uniform control of the degree of arcing.

The majority of this discussion of newly developed aircraft resistance welding equipment has centered about the stored energy method. The process described first, which does not utilize the stored energy method, nevertheless aims at accomplishing the same results by a somewhat different principle.

The question naturally rises "Why stored energy?" The reasons are logical and conclusive and are borne out by the results when compared with the conventional A. C. process. They can be briefly summed up as decreased power consumption, improved quality of welds and higher production.

While perhaps not the most important reason for the initial development of the use of stored energy for resistance welding, but probably the first, is the problem of power supply. Low contact resistance and low internal resistance of the light alloys used in aircraft necessitate the application of an extremely high current to obtain sufficient heat for welding. This means that a very high kva. value is required to overcome the impedance of a standard secondary circuit. When using the conventional A.C. method with electronic control, there is a high instantaneous demand on the power system. This load is always single phase and at a very poor power factor. This unbalanced load of low power factor creates a very undesirable condition in three-phase systems. It interferes with the functioning of other electrical equipment in the system and causes trouble at the central power station. Penalties are usually imposed by power companies for this type of load. Currents being heavy and of low power factor, even though they are intermittent, make necessary the installation of heavy power lines which are quite expensive. To combat the poor voltage conditions created it was usually necessary to install large and expensive transformers for spot welders only. This condition was bearable when plants had only one or two machines, but in these days of rapid plant expansion when ten to twenty machines in one plant are common, it would have been an almost impossible situation but for the use of stored energy. It should be brought out, however, that impartial surveys have been made comparing the cost of installing and operating A.C. type of machines against stored energy types. The installation costs of the two are about equal. However, operating costs definitely favor the stored energy types when tip life, improved line power factor, higher production and other items are taken into account. The method by which the use of stored energy reduces kva. demand is simple. The

storage system receives its charge over a relatively long period of time, although it is discharged in a very short time. This long storage time, which is the time when power is being taken from the supply line, thus creates no high instantaneous demand. Interposing a three-phase rectifier between the power supply and the storage system gives a balanced load of inherently high power factor. Another important feature is that consistency of welding currents is less affected by line voltage variations in stored energy machines than A.C. machines.

The second reason lies in the inherent welding characteristics of the light alloys themselves. The reason why resistance welding of the light alloys presents more problems than the ferrous alloys can be attributed to two characteristics, their relatively high thermal and electrical conductivity and their critical melting point. The former means high currents are necessary and the latter means they must be very accurately measured to confine the resulting temperature within a very short range. There has been some talk of the "wave form" best suited for the material to be welded. At the present date discussion of this subject must be limited almost entirely to theory. The best "wave form" for welding a particular metal is a function of the metallurgical, electrical, thermal, and other characteristics of the metal, all of a complex nature and involving a very thorough investigation to properly evaluate this wave form. However, we do know that the light alloys require high currents and the application of these currents must be limited to a very short time. The energy delivered by stored energy type welders conforms to these requirements. Therefore, it can be said that, in general, the wave form of stored energy welders or, to use a term descriptive of all four types mentioned, single impulse welders, is more suitable for welding light alloys than an A.C. wave form. These single impulse machines permit alteration of wave forms. However, at the present, this alteration of wave form for different materials is limited to the use of short-duration waves for light gages and longer-duration waves for heavier gages.

As a third reason for the use of single impulse welders, the production of higher quality welds at as high or higher production rate is emphasized. This might be better stated as an inherent feature of this method. Higher electrode pressures are possible with the higher current values. This is a definite step in the elimination or minimizing of weld cracks and porosity. The use of shorter welding time has also contributed to this as well as causing less effect of the heat on areas of the parent metal adjacent to the weld region. Pick-up of metal on welding tips is considerably decreased thus cutting down the frequency of tip cleaning and permitting higher production. The external appearance of the weld is improved in that there is less deformation of the sheet and less of a tendency to "burn" or oxidize. Summing up these qualities, welds made by the single impulse method are definitely of higher mechanical strength and possess a great degree of uniformity. This makes possible the designing of spot weld stressed members with an exactness approaching that of riveted construction.

This paper has made no definite attempt to evaluate the superiority of one type of equipment over the other. I have only attempted to present in a general manner the present status of aircraft resistance welding and resistance welding equipment. It is my opinion that single impulse welding will eventually completely replace the A.C. method for resistance welding of light alloys, and that this is only the beginning of an intensive development of the use of spot welding in aircraft.

Statement of the Ownership, Management, Circulation, etc.

REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

OF THE WELDING JOURNAL, published monthly at Easton, Pa., for October 1, 1941.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and County aforesaid, personally appeared William Spraragen, who, having been duly sworn according to law, deposes and says that he is the Editor of THE WELDING JOURNAL and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

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Editor, William Spraragen, 33 W. 39th St., New York, N. Y.

Managing Editor, William Spraragen, 33 W. 39th St., New York, N. Y.

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W. SPRARAGEN, Editor.

Sworn to and subscribed before me this 17th day of September, 1941. (Seal) MARY T. HICKEY

Notary Public, New York County Clerk's No. 172.
New York County Register's No. 2-H-76.
(My commission expires March 30, 1942.)

A. W. S. Minimum Requirements for Training of Welding Operators*

By L. M. Dalcher†

IN THE September issue of THE WELDING JOURNAL, the Society published the first part of a proposed "Code of Minimum Requirements for Instruction of Welding Operators." This report was the work of an AMERICAN WELDING SOCIETY technical committee, known as the Committee on Minimum Requirements of Instructions for Welding Operators in Trade Schools. In this article it is proposed to review the factors which led the Society to appoint this Committee, to state some of the problems which the Committee had to face, to explain the program which is now being carried out, and to describe some of the benefits which it is hoped will result from adoption of the proposed Code.

States Need Standard of Acceptability for Trade Schools

There were a number of circumstances which led to the appointment of the Committee, but if we were to seek the hand that first started the ball rolling, we would probably find it to be that of the New York State legislature. Some time ago that state passed a law making it mandatory for trade schools to secure a license before starting operations. The Department of Education, faced with the task of granting the licenses, soon found that the welding schools presented a very perplexing problem. Their facilities, courses and methods of instruction varied so widely from one school to the next that it seemed almost impossible to arrive at any sound criteria on which to base the granting of licenses.

With a cry for help, the Department of Education came to the AMERICAN WELDING SOCIETY. Could not we, as a national society representative of all the interests concerned, create an authoritative standard of acceptability for welding schools? The Society carefully considered the request, investigated the need for the project, found that other states were facing a similar problem, and concluded that something could be done about it. And they did—they appointed a Committee on Minimum Requirements of Instructions for Welding Operators in Trade Schools.

Welding Schools Seek Guidance in Planning Courses

There were also a number of other reasons for the Society's undertaking this project. One of these was that the welding schools themselves have on numerous occasions asked the Society for advice and guidance in laying out their courses. Particularly is this true within the last year, when trade schools have sprung up like mushrooms and the government has organized hundreds—probably thousands—of defense training classes. In some instances the courses were being organized by persons who had had no background of experience in welding, who nevertheless were anxious to do a good job, but who admitted frankly that they had no adequate conception of what their task required. Even some of the long-established and reputable welding schools indicated that they would welcome authoritative guidance.

In preparing its report, the Committee has kept this need very carefully in mind. Witness the content of the published Code. The first section is the mandatory part, all provisions and requirements of which must be fulfilled by any welding course which is to be considered as complying with the Code. This section contains the minimum requirements—the standard of acceptability which the states and others have been seeking. But the second part—and it is larger than the first—contains only recommendations, suggestions intended to help welding schools in organizing their courses.

Better Schools Require Protection to Maintain High Standards

The welding schools also made another kind of request which the Society hoped would be fulfilled by the work of this Committee. This time the request came not from the newly organized schools, but from some of the schools that had been in business for many years and were known to be giving a high grade of instruction. They reported that some of the newer welding schools were offering courses for considerably lower fees, and making this practice possible by shortening the time of instruction. The established schools did not want to shorten their courses, as they knew they could not give their students the same high quality of training. And yet the competition was making it increasingly difficult for them to maintain their high standards.

Welding schools that have seen the proposed Code are confident that it will provide the solution to the problem. They will then be able to state in their literature that their courses conform to the Code of Minimum Requirements of the AMERICAN WELDING SOCIETY. In this way the Code will achieve two of its important objectives: first, it will create a fair basis for competition among the trade schools; second, it will encourage the poorer welding schools to raise their standards.

Government Agencies Require Standards for Welding Instruction

Another reason for the appointment of this Committee was a situation which arose out of the country's defense efforts. With the expansion of construction work under the Navy Department, War Department and other

* Presented at the Annual Meeting, A. W. S., Philadelphia, Pa., Oct. 20 to 24, 1941.

† Secretary, Committee on Minimum Requirements of Instructions for Welding Operators in Trade Schools.

federal agencies, a demand was created for large numbers of welding operators—more than could be obtained under the established civil service procedures. Government employees of this kind are selected on the basis of civil service examinations, and heretofore it has been required that the applicant have had a certain length of welding experience in industry—sometimes as much as two or four years on a particular type of work. To meet the present emergency it has been necessary to change these requirements and to accept applicants who have not had experience in industry, but who have been properly trained in a public or private trade school.

This is the point at which the real problem arises: How can we be sure that these applicants have been properly trained? There is a ready answer that occurs to all of us: Test them and see. But this is not the answer. It is wasteful, costly in time and expense, and is not permitted under the civil service regulations. The problem boils itself down to this: How can we state the requirements in the announcement of the examination? To specify that the applicant must have completed "a course in welding" or "a six months' course in welding" is not enough. Some schools give adequate training in that time—others do not. What is needed is a recognized standard for welding instruction.

The Committee has kept this need in mind, and it is expected that the Code, when finally adopted and published, will provide the solution to the problem. Then it will be possible for the announcements to state, as an alternative to the experience requirement: "Applicants shall have completed a course in welding conforming to the A. W. S. Code of Minimum Requirements for Instruction of Welding Operators."

Public Seeks "Approved" Welding Schools

The Society is frequently asked by individuals to recommend a welding school, or to furnish a list of "approved" welding schools. Up to now we have not been able to provide such people with very much help. We could not, as an unbiased engineering society, recommend one school in preference to another, even if we happened to know which was the best school in a given state or district. Neither could we inspect all the schools and issue a stamp of approval, because of the immensity of the initial task and the impossibility of policing the ratings once established. There would be nothing to prevent a school from obtaining an "approved" rating, and then lowering its standards.

In the past the Society has answered such inquiries by providing a list of *all* the welding schools in the given district, and suggesting to the inquirer that he visit as many of the schools as possible, examine the facilities available and the content of the courses, and then decide for himself which school offers the best training for his purpose. As a matter of fact, people who took this advice usually made a wise selection. Nevertheless, it was apparent that this was not the ideal solution to the public's problem.

A much better solution will be available when the Code of Minimum Requirements is adopted. Schools whose courses meet these requirements will undoubtedly advertise that fact, and it will give the prospective student a good basis for comparing one welding school with another.

Other Parts of Code to Be Prepared

The question may next be asked: How many other parts of the Code does the Committee intend to issue? At this time we can answer: At least one,* possibly more. Perhaps a better answer would be an explanation of the procedure which the Committee has adopted in carrying out its assignment.

One of the first problems which the Committee had to face was the fundamental one of deciding how to regard the subject, that is, whether to regard welding as a trade complete in itself, or whether to consider it in the light of its application to a great number of widely different trade and industrial fields. If the Committee had decided to regard welding as one separate trade, it would have meant prescribing instruction that would train the student to do all kinds of welding—arc welding of heavy plate and pipe, of thin sheet and tubing, of various alloys as well as steel, and the same things with gas welding. But the Committee chose the second alternative, and automatically took upon itself the task of writing more than one set of requirements. There would have to be one set of requirements to cover the kind of welding used in shipbuilding, another set to cover aircraft construction, possibly another set to cover structural welding, and so forth.

Of course the Committee realized it would be an impossible task to write a separate code for all of the many specialized fields of welding. It was felt, however, that there were certain fundamental principles and techniques which apply to all types of manual welding, and that any instruction in the specialized fields should include thorough training in these fundamental elements, plus additional instruction in the techniques peculiar to the field of specialization. In conformity with this interpretation, the Committee decided to formulate minimum requirements for instruction in the fundamental principles and techniques of welding.

For practical reasons, it was necessary to separate the fundamental techniques into four main subdivisions, namely:

(1) Arc welding of thick material.
(2) Arc welding of thin material.
(3) Gas welding of thick material.
(4) Gas welding of thin material.

By thick material the Committee meant plate and pipe $^3/_{16}$ in. thick and over; by thin material they meant light sheet and tubing. Because it seemed to be needed the most urgently, the Committee undertook first to draft requirements for instruction in arc welding of thick material. It is this subject that has been covered in Part A of the Code. The next subject to be covered will be subdivision (4), gas welding of thin material, because of its current importance in the field of aircraft construction.

Advantages in Having a Code of Minimum Requirements

In conclusion, let us see what it will mean for the Society to have a widely recognized Code of Minimum Requirements for Instruction of Welding Operators. In other words, what will we have accomplished from the standpoint of benefit to the state and federal agencies, to the industries that hire welding operators, to prospective students of welding, and to the welding schools themselves?

For the states we will have provided: first, an authoritative standard of acceptability for welding schools,

* Probable title: "Part B—Gas Welding of Sheet and Tubing."

which they can use as a basis for granting licenses; and second, a useful guide for organizing welding courses in the public vocational schools.

For the federal agencies we will have provided: first, a standard of welding instruction which can be cited as a requirement for employment under the civil service, thus making it possible for the government to hire properly trained applicants who have not had experience in industry. Second, we will have provided much information that will benefit the welding classes under the defense training program.

To the industries that hire welding operators, the Code will be of considerable help, particularly after the welding schools have had a chance to put it in effect. For one thing, the Code will raise the general standard of welding schools throughout the country, and thereby provide better trained men for industry to hire. This should mean a considerable saving, as it will reduce the amount of training necessary in industry itself, and will provide operators who can be advanced rapidly to work of greater importance. The Code will also serve another important function in this connection: It will help to make industry realize what can reasonably be expected of the man trained in a welding school. The proposed Code contains the following statement on this subject: "The course is not expected to produce an experienced operator, but rather an operator with enough skill and knowledge so that he will have immediate value to industry as a welding operator on less difficult work, and will be able, by gaining experience in industry, to progress rapidly to work of greater difficulty." When this fact becomes more widely appreciated, there will be closer cooperation between industry and the welding schools, to the greater benefit of both.

For the prospective student of welding, the Code will provide a number of important benefits. First, by raising the general standard of welding instruction, it will enable him to obtain better training. Second, it will give him a good basis for comparing one school with another, and deciding which of several schools is likely to give the best course for his purpose. Third, it will, as we have seen, make it easier for him to obtain employment after he has completed his training.

Lastly consider the advantages which the Code offers to the welding schools themselves—and these are probably the most important of all. In the first place, it will provide authoritative guidance to help them in organizing their courses. In the second place, it will provide a means of protection for the better welding schools, to enable them to maintain their high standards against competition from schools that charge lower fees, but give less adequate training. Finally, there will be a number of indirect benefits which we have already seen—from being able to place their students directly in government employment, and from the promotion of closer cooperation between the welding schools and industry.

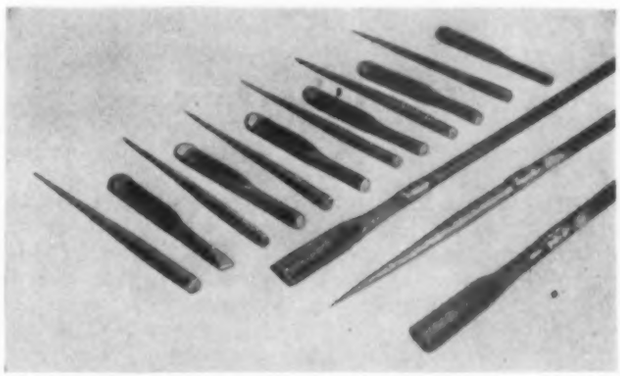
Joining Brass to Steel

By J. S. Graham, Jr.*

THE readiness with which dissimilar metals, such as brass and steel, can be joined by bronze welding is demonstrated in the fabrication of drill-hole cleaning tools, which are used in large quantities by mines. These tools, which are used to clean out drill holes before they are charged for blasting, consist of a length of round steel bar stock, to one end of which is joined a brass spoon and to the other a brass pin or punch. The spoon is used to remove mud and chipped rock from the hole, while the punch is used to dislodge pieces of rock that have become jammed. The punch also proves a handy tool for removing drills that have broken off in hole, for its point can be rammed into the drill center to make a press fit and the punch withdrawn with the drill attached. These ends of the tool are made of brass to eliminate any possibility of striking a spark in case some powder might be present in the hole.

Formerly it was customary to assemble the cleaning tool by means of mechanical joints—either keyed or threaded—but these methods never proved satisfactory for there was a tendency of the parts to uncouple, or there was either undesirable bulkiness or excessive breakage at the joint. Whenever the tool broke, it was difficult to remove the broken part from the hole, with a resulting loss of time in addition to the material loss of the damaged tool. When the mechanical joint was strengthened to overcome breakage, the increased bulk at the joints reduced the tool's efficiency.

* The Linde Air Products Co., New York, N. Y.



These Brass Punches and Spoons, Shown Lined Up in the Background, Are to Be Bronze Welded to the Ends of Round Steel Bars. The End of the First Spoon (Second Object from the Left) Has Been Ground to a Chisel Shape in Preparation for Welding. In the Foreground Are Several Completed Tools

Bronze-Welding Procedure

The substitution of a bronze-welded joint for the various types of mechanical joint has proved an entirely satisfactory solution. The joint is prepared for welding by grinding the end of the brass part to a chisel shape and butting this against the end of the bar which is left square. Sometimes the end of the steel bar is also beveled so that the included angle between the two beveled ends will give a wider vee for welding. Standard bronze-welding technique, with a slightly oxidizing flame, is followed, using bronze-welding rod and flux. A light grinding of the weld removes any surface irregularities and improves the appearance of the tool.

Cost of the bronze welding is only a small fraction of the cost of a machined and fitted joint. The finished tool is neat and well balanced with no increase in bulk and only a minimum of increased weight at the bronze-welded joint. Performance data indicate that the life of this joint is as great as, or exceeds, that of the tool itself.

The Handling of Ni-Clad Steel

By Joseph V. Kielb*

THE cutting and welding of Ni-clad steel has caused much discussion in many industrial plants. The development of this product has attracted the attention of many large companies who fabricate corrosion-resisting steel extensively. Most of this steel, to date, has ranged from 1/4 to 1/2 in. in wall thickness with the clad thickness usually being 20% of the over-all thickness of the wall; but now heavier wall thicknesses are used. Although conditions vary slightly in each plant, the following facts apply generally.

Joint Design

Beveling of this material for welding presents a big problem. Usually the included angle of bevel on the carbon steel side ranges from 45 to 75° for the butt groove, depending to some extent upon the conditions existing within. The angle 60° is most commonly used at present, but in time to come the angle 45°, or less, will prevail. The clad side is usually a common U groove, with a degree of bevel varying from 7 to 20°, having a radius of 1/4 in. as illustrated in Fig. 1, or it may have a butt groove, similar to that of the steel, if the automatic flame cutting is successful. In the preparation of the clad groove, the amount of metal removed should be as small as possible, so that the replacement of weld metal can be kept to a minimum. This lowers the welding cost of the nickel-clad side, which is considerably more expensive than mild steel welding. After determining the degree of beveling, the cutting of this material proved to be very difficult due to the presence of nickel with the steel. The physical cutting characteristics of nickel differ from those of mild steel, particularly when heavy wall thicknesses of nickel are involved. After much study, several types of experiments were tried in order to find the best way to cut this material.

Joint Preparation

The first method tried was the application of direct automatic flame cutting of Ni-clad steel as a single unit, but it was not so successful as had been hoped. This method required special technique in the handling of the cutting torch, which had to be sloped from 10 to 20° in the line of direction of the cutting; furthermore, it had to be sloped to the proper angle for beveling the plate on the steel side. The size of preheat and cutting orifices had to be approximately one and one-half to two times as large as the required size in the cutting of mild steel in order to obtain sufficient preheat before starting to cut and during the process of cutting.

At one time during this method, it was necessary to maintain a large preheat flame on the side of the clad in order to heat the nickel to a greater degree so that the steel and nickel would cut as one unit. On several occasions the steel could be cut, but not the nickel which resulted in a large gouge between the steel and the nickel. The molten steel spattered against the nickel and was deflected from its surface into space, or reversed itself and clogged the preheat orifice, both of which resulted in an unsatisfactory cut. When a successful cut was obtained at the edge of the plate, then a continuous cut had to be made as it proved to be difficult to start the cut again, due to the formation of oxides from the nickel. In addition to these difficulties there was the possibility, due to the enormous heat, of granular structure changes being created in the zone where the nickel came in contact with the steel, thus lowering the corrosion resistance qualities of the nickel. Another point leading to this result was the possible pick-up of carbon in the nickel from the steel. The results obtained proved that the cutting cost was very high and required too much precision in order to properly prepare the joint for welding.

The most successful method (the one now used) is the chipping of a common U groove into the nickel, with the aid of pneumatic hammer and gouging tools until reaching the inner surface of the steel, as illustrated in Fig. 1. Care must be taken not to chip too wide a groove, necessitating too much nickel weld replacement. An ordinary automatic flame-cutting machine is then applied to the steel surface to obtain the required degree of bevel. This surface on the steel side should be perfectly smooth, lacking ridges of any size, because welders have a tendency to trap slag in these ridges; therefore, the bonded areas are weakened, which results in poor physical tests. The X-ray will reveal this porosity, which may also prevail in the first few layers of weld metal, on the side walls of the bevel. This method has proved to be the most economical in the handling of this kind of steel and, although one of the oldest methods of joint preparation, it is still used extensively throughout many plants.

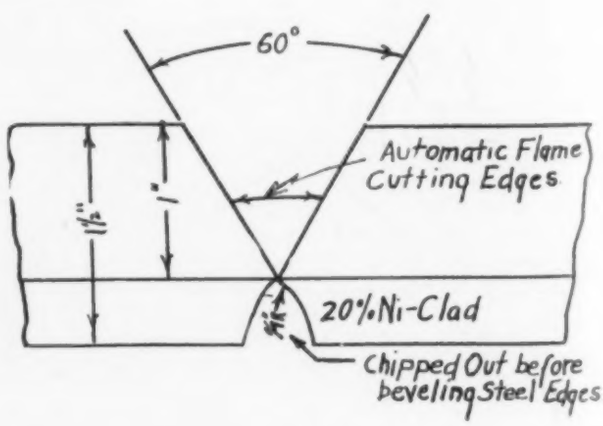


Fig. 1

* Welding Supervisor Industrial Welding & Machine Works, Long Island City, N. Y.

In fitting up the groove of this steel certain sections of the root opening were flush while other sections had an opening as large as $^{3}/_{16}$ in., the welding of which presented a difficult problem. In tacking steel of this sort, it has been observed that the welded tacks developed longitudinal cracks upon the completion of each weld. On several occasions the tack welders had to reinforce the tacks by placing another bead on those previously broken. These were later chipped out before placing the first welded layer. After careful study, it has been found that a great strain between the U groove and butt groove was created, due to the coldness of the base metal and the diffusion of some part of the nickel into the welded mild steel tack which formed intergranular structures. Another point discovered was the use of too large electrodes, having straight polarity, which resulted in cracked welded tacks. This problem is encountered in putting the first layer in the butt groove of the mild steel surface, resulting in a complete longitudinal crack in the weld which has to be chipped out later.

These difficulties, after close consideration, have been eliminated: first, by the aid of reverse polarity electrodes of small diameter; second, by the groove being preheated to reduce the coldness of the base plate and the distortion which tends to create part of the strain in the groove. If preheating is not used, then the weld area at the root of the steel side should have a minimized heat temperature; therefore, the use of $^{1}/_{8}$-in. electrodes having reverse polarity is recommended in order to secure higher ductility than that of a straight polarity electrode of the organic type. The latter are excellent when the fit-up is poor and where very high tensile strength is necessary, also the spatter losses are lower when using an electrode of this sort than that of the reverse type. Many of the welders for the reason just mentioned like straight polarity electrodes, but they fail to give consideration to the greater penetration required in the bonded walls of the given groove and the fact that greater elongation is secured by the reverse polarity electrodes, which is more important than spatter loss. Later it was found by tacking the plate on the clad side first with an alloy electrode that rigid tacks were obtained which were chipped out before welding the clad side in order to receive complete penetration in that section.

After tacking the plate, the V bevel groove is then completely welded. Here two schools of thought are involved; some men believe in welding the clad groove first and the steel second, while others believe in welding the mild steel groove first and the clad second. Both methods were tried and it was determined that welding the steel groove first was best because it eliminated the diffusion of nickel into the steel-welded groove, and also eliminated the possibility of reducing the corrosion resistance qualities of the nickel. In addition, the chipping in the groove from the steel side after the clad has been welded will reduce the wall thickness of the nickel; therefore, corrosion would start first in that zone. There is also the possibility of a lack of complete penetration in the zone where the V groove and the U groove come together.

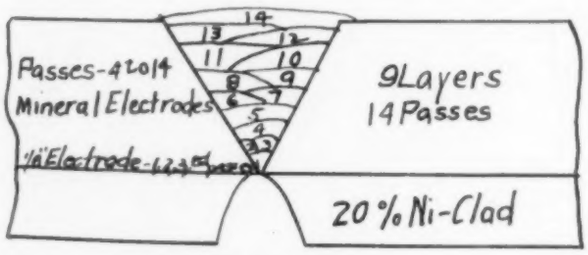


Fig. 2—Welding Sequence of Steel

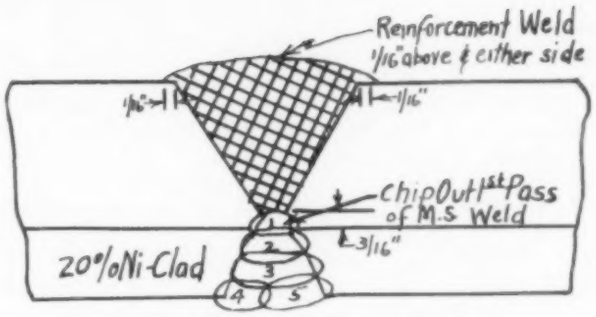


Fig. 3—Welding Sequence of Clad

Welding Procedure

The following welding procedure has been proved to be best for the existing conditions; small-diameter mild steel electrodes having reverse polarity are employed as illustrated in Fig. 2; thus the diffusion of nickel into the weld metal of the steel is reduced to a minimum and the strain is reduced by minimizing the weld temperature of the first and second layers. If large electrodes of either straight or reverse polarity having organic or mineral coatings are used at the start, when the groove is not preheated, the spatter loss would be very high, ranging from 30 to 40%, due to enormous welding heat of the electrode and the diffusion of too much nickel into the mild steel weld metal. The results obtained from the use of these electrodes were very costly because of the high spatter losses sticking on the side walls of the groove, which required a great deal more chipping and cleaning of each layer in the groove. In Fig. 2 it will be seen that the first two layers which have three passes show that $^{1}/_{8}$-in. diameter electrodes have been applied, carrying a minimum amount of amperes, 80–90, thereby reducing the diffusion of any nickel into the mild steel weld metal. The balance of the welding sequence of the groove can be easily controlled by applying mineral-coated electrodes of various sizes depending on the opening existing in the groove after each layer has been deposited. Sufficient time should elapse between the layers of weld metal in order to reduce the temperature of the welded area, thereby keeping distortion to a minimum. The sequence employed in placing the welded layers shows that the rate of deposition of the weld metal would be very shallow to avoid the creation of enormous welding heat and to reduce the possibility of trapping porosity which would be visible in X-ray testing.

Another method for welding the steel groove would be to use a mild steel electrode having a 3% nickel content. This would help to keep the spatter losses normal even though the cost is slightly higher per foot of weld metal. This electrode could be used for tacking when fitting up the shell and heads of tanks, thus eliminating much of the trouble previously encountered. It would be a time-saver in tacking and welding the steel butt groove and in the long run would prove best to apply.

When using mineral-coated electrodes in welding this steel or any Class I steel, under A. P. I., alternating current should be used to eliminate the magnetic blow which exists when welding with direct current. If alternating current is not available, then the use of direct current with reverse polarity is best for this particular job, in order to keep the spatter losses down to normal.

Electrodes of this type should not be used in the first and second layers of the steel groove because of the great amount of heat required for the proper handling of this electrode; furthermore, the fit-ups would not be flush throughout the head and shell of the tank, causing the molten metal to fall through the groove and hang on the inside of the U groove, making excessive chipping necessary. If direct current with straight polarity is used with mineral-coated electrodes it will be noticed that there will be an irregular peeling of the coating which makes it hard for the welder to control the flow of the molten metal in the groove, resulting in much trapped porosity which requires a lot of chipping before applying the next pass.

In the welding of the clad side, the first layer of weld metal deposited by the mild steel electrode is chipped out from the root of the clad to a depth of $^{3}/_{16}$ in., then the weld metal is inspected for cracks, which are usually visible to the eye. If any cracks are found they should be eliminated before applying the alloy electrode to the clad groove. The proper welding sequence for the clad side is illustrated in Fig. 3. An alloy electrode $^{5}/_{32}$ in. in diameter was used exclusively on this side. The reinforcement of the clad side is $^{1}/_{16}$ in. above the surface of the parent metal, similar to that of the steel groove, as shown in Fig. 3.

Particular care must be taken in handling this electrode so that pinholes are not created which are usually found upon finishing one electrode and starting another. Failure to clean the crater and to get penetration at this point is a common fault among welders. At that zone, flux is trapped which causes these minute pinholes, thus aiding corrosion. Some plants have a tendency to peen each pass of this metal, thereby eliminating these pinholes but creating other problems which they fail to take into consideration. Peening is dangerous in most cases, so more thought should be given before trying it. Time after time these pinholes are found to be visible after machining, especially when dealing with manholes and nozzles for these tanks, also when dealing with the inside seams of the tank which are chipped down flush, ground and finally buffed to give a polished finish. When these holes are found, they are chipped out and rewelded. Too many jobs are chipped and rewelded which results in higher welding cost, so more care and time should be given to complete the job correctly the first time.

The conditions as explained in this paper may be of some aid to companies encountering a similar job. This technique and procedure of Ni-clad steel can also be applied to the welding of stainless steel clad, of heavy wall thickness.

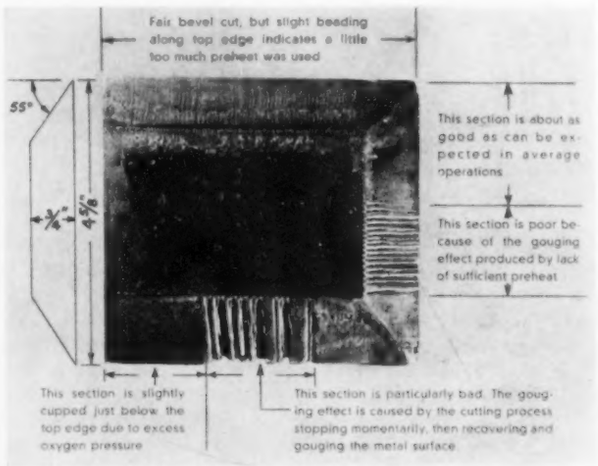
Use More Preheat for Bevel-Cutting

By B. H. Higgs*

THE accompanying photograph indicates better than words can describe what happens when insufficient preheat is used for bevel-cutting steel plate with oxyacetylene cutting machines.

The reason that more preheat is required for bevel-cutting than for vertical-cutting operations is that the blowpipe is at an angle to the plate surface. Because of this, the heat tends to "bounce off" and does not penetrate to the same extent as when the preheat flames strike the plate at right angles. Obviously, the flatter the angle of cut, the greater amount of preheat required.

There are a number of ways to obtain more heat. For normal beveling up to angles of 45°, sufficient preheat can be obtained with standard nozzles by slightly "forcing" the preheat flames as the angle of bevel increases. For very shallow angles it is sometimes necessary to provide supplementary preheat, either with a second blowpipe or else by first going over the line of cut with the cutting blowpipe. A size larger nozzle or slightly slower cutting speeds also are of help sometimes. Because of the high temperature of the oxyacetylene flame, acetylene offers special advantages for beveling where preheat requirements are greater than for normal severing.


Fair bevel cut, but slight beading along top edge indicates a little too much preheat was used
55°
¾"
4⅝"
This section is about as good as can be expected in average operations
This section is poor because of the gouging effect produced by lack of sufficient preheat
This section is slightly cupped just below the top edge due to excess oxygen pressure
This section is particularly bad. The gouging effect is caused by the cutting process stopping momentarily, then recovering and gouging the metal surface

Compare the Good and Poor Cuts in This Unretouched Photograph of $^{3}/_{4}$-In. Steel Plate Which Has Been Beveled on Three Sides. In Taking the Photograph, Special Lighting Has Been Used to Accentuate the Defects

When selecting the correct size nozzle to use, the depth of the actual cut should be considered rather than the thickness of the plate.

A study of the various cut surfaces in the illustration should aid the machine-cutting operator in obtaining maximum results in bevel-cutting operations.

* The Linde Air Products Company, Salt Lake City, Utah.

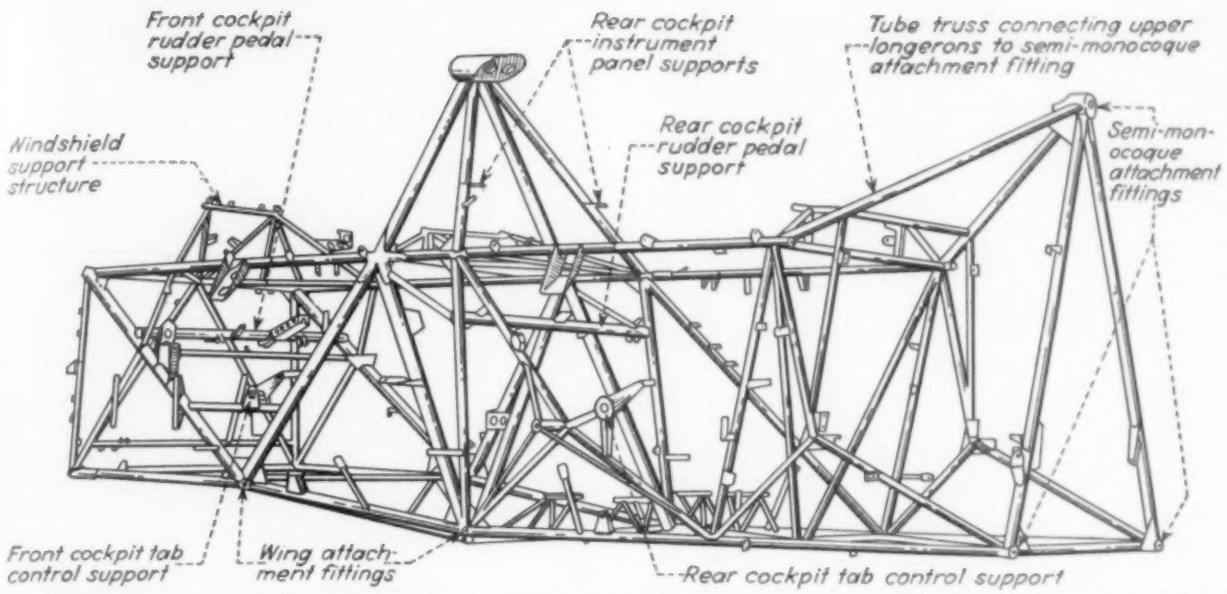

Front cockpit rudder pedal support
Rear cockpit instrument panel supports
Tube truss connecting upper longerons to semi-monocoque attachment fitting
Windshield support structure
Rear cockpit rudder pedal support
Semi-monocoque attachment fittings
Front cockpit tab control support
Wing attachment fittings
Rear cockpit tab control support

Fig. 1—Reproduction of Typical Tubular Fuselage Structure. This Will Indicate Some of the Problems, Particularly Accessibility for Welding

Management Control of Design and Welding of Aircraft Steels*

By J. P. Dods†

BY MANAGEMENT Control we mean the direction by proper authority to bring about the cooperation between department heads in charge of design and production of all parts and structures. Of course, this cooperation of personnel may include many men working on a given problem. For the most part we will be referring to fabrication by welding of steels, particularly tubing, sheet and forging, although the general principles having to do with Management or Procedure Control will apply equally well to other forms

* Presented at the Annual Meeting, A. W. S., Philadelphia, Pa., Oct. 20 to 24, 1941.

† Research Engineer, Summerill Tubing Company, Bridgeport, Pa.

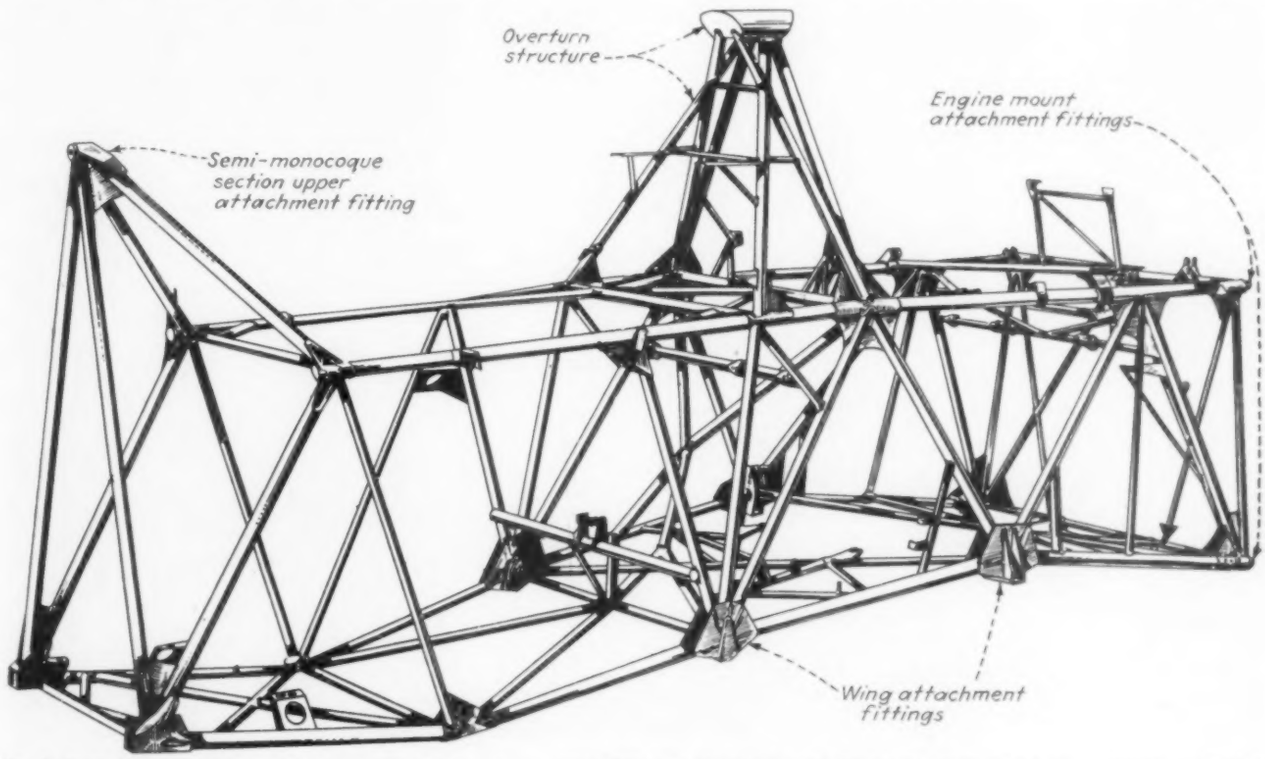


Fig. 2—Reproduction of Typical Tubular Fuselage Structure. This Will Indicate Some of the Problems, Particularly Accessibility for Welding

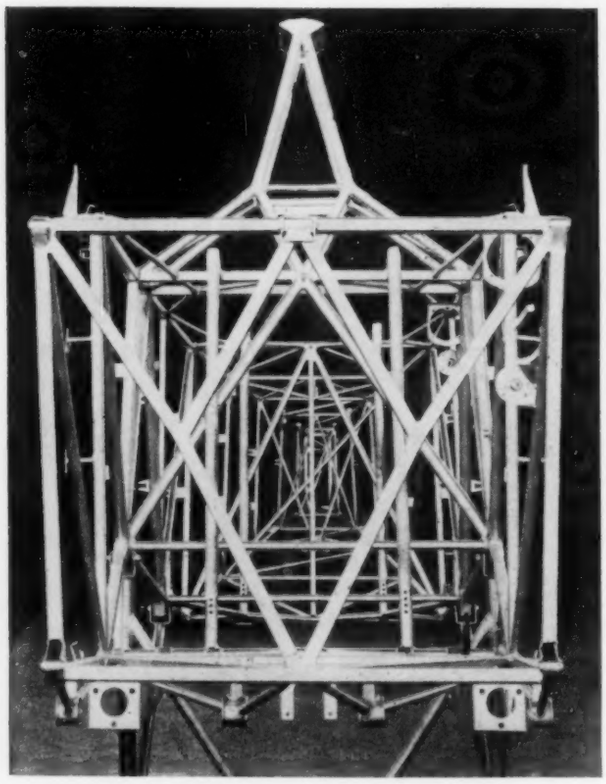


Fig. 3—An End View of Steel Tubular Fuselage

of materials. No attempt is made, or desired, to suggest the details of welding technique. It is our hope that some of the suggestions may be of assistance in obtaining a basis for standardization of welding procedure.

To many men in older industries, some of our thoughts may seem wholly unnecessary; the only excuse for this paper is the short life of aircraft production and its rapid growth in the last two years. There is one basic factor which we believe is fundamental in approaching the subject as it applies to the industry.

The airplane is the first means of transportation which has not travelled on water or on wheels in world history. There are not, and never have been, any problems in mathematics for any previous vehicle comparable to that required for aerodynamic design and stress analysis.

Ever since the Wright Brothers' successful flight at Kitty Hawk, practically all of our aviation technical knowledge and training have been expended along aerodynamic lines, i.e., to produce better flying characteristics. For years our technical schools with aeronautical departments have devoted all their time to turning out young engineers with all of their training along aerodynamic lines. While it may be true they have had some work in the design for utilization of wood, wire, aluminum and steel, I do not know of a single college, having shop training, giving these men the fundamental knowledge on the problems of sheet metal work, welding and forgings for aircraft manufacture. The design for an aircraft part may meet all the requirements of the ANC allowables, but still have little or no consideration for the manufacturing problems involved.

The National Advisory Committee for Aeronautics has in operation, or building, research laboratories costing approximately $30,000,000, and not a single building is set up for research on the joining or fabrication of materials. All of the research so far planned, as we know it, is on aerodynamics and power plants. Some test work is going to be made on structures, but not on their fabrication.

Events have moved so swiftly in recent months that most of us are apt to forget that before October 1939 not one manufacturer in this country had ever received a single order for more than 100 or 200 planes of the same type. The delivery of these planes were scheduled to cover many months, and in all probability numerous changes took place before the order was completed.

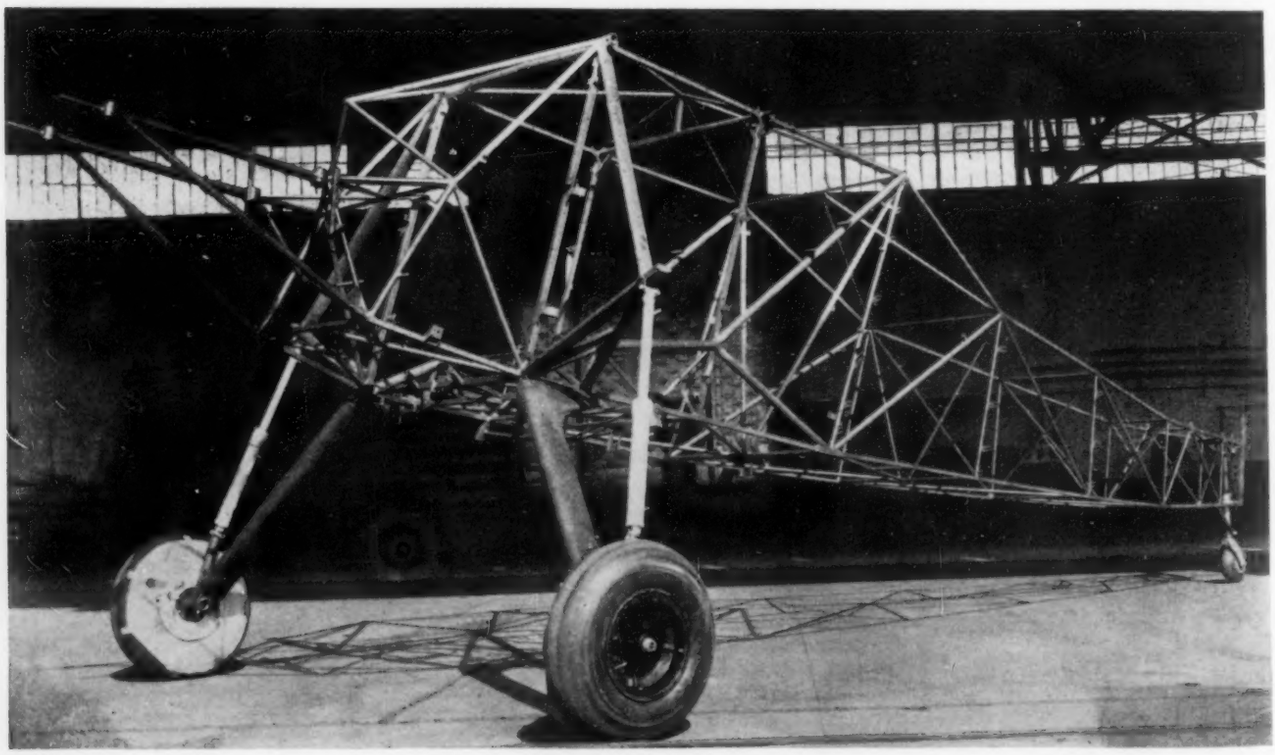


Fig. 4—Steel Tubular Fuselage of Fairchild Model 24

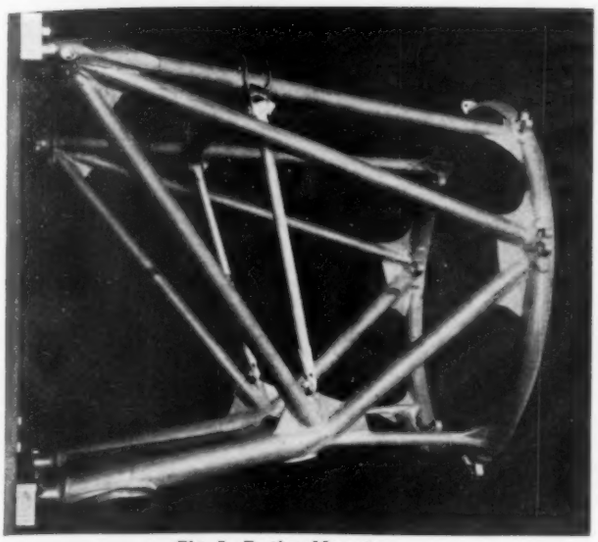


Fig. 5—Engine Mount

Under such conditions, no manufacturer could be expected, or would find it practical to set up manufacturing plans along the production lines common in other major industries.

It is also important to realize that most of the men entering this industry have been young; most of them with flying experience and a lot of faith and enthusiasm for the future of aviation, but for the most part with none, or very little, metal working or manufacturing knowledge. These men have not only had to organize, guide and direct a new business, but also assist in developing a new manufacturing technique. In most cases, things were put together piecemeal. Until two or three years ago, each plane was almost a handmade job.

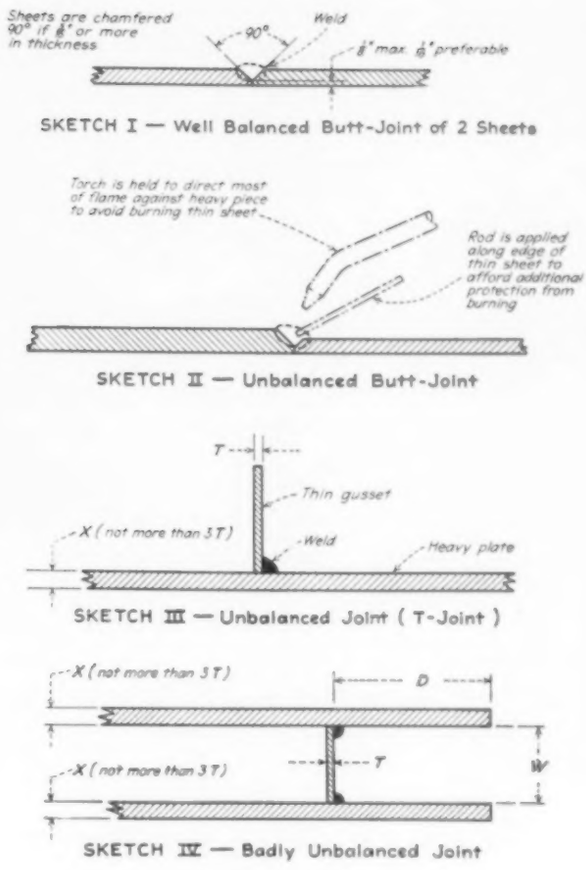

Sheets are chamfered 90° if ⅛" or more in thickness
90°
Weld
⅛" max. ¼" preferable
SKETCH I — Well Balanced Butt-Joint of 2 Sheets
Torch is held to direct most of flame against heavy piece to avoid burning thin sheet
Rod is applied along edge of thin sheet to afford additional protection from burning
SKETCH II — Unbalanced Butt-Joint
T
Thin gusset
X (not more than 3T)
Weld
Heavy plate
SKETCH III — Unbalanced Joint (T-Joint)
X (not more than 3T)
D
T
W
X (not more than 3T)
SKETCH IV — Badly Unbalanced Joint

Fig. 7—Joints Balance

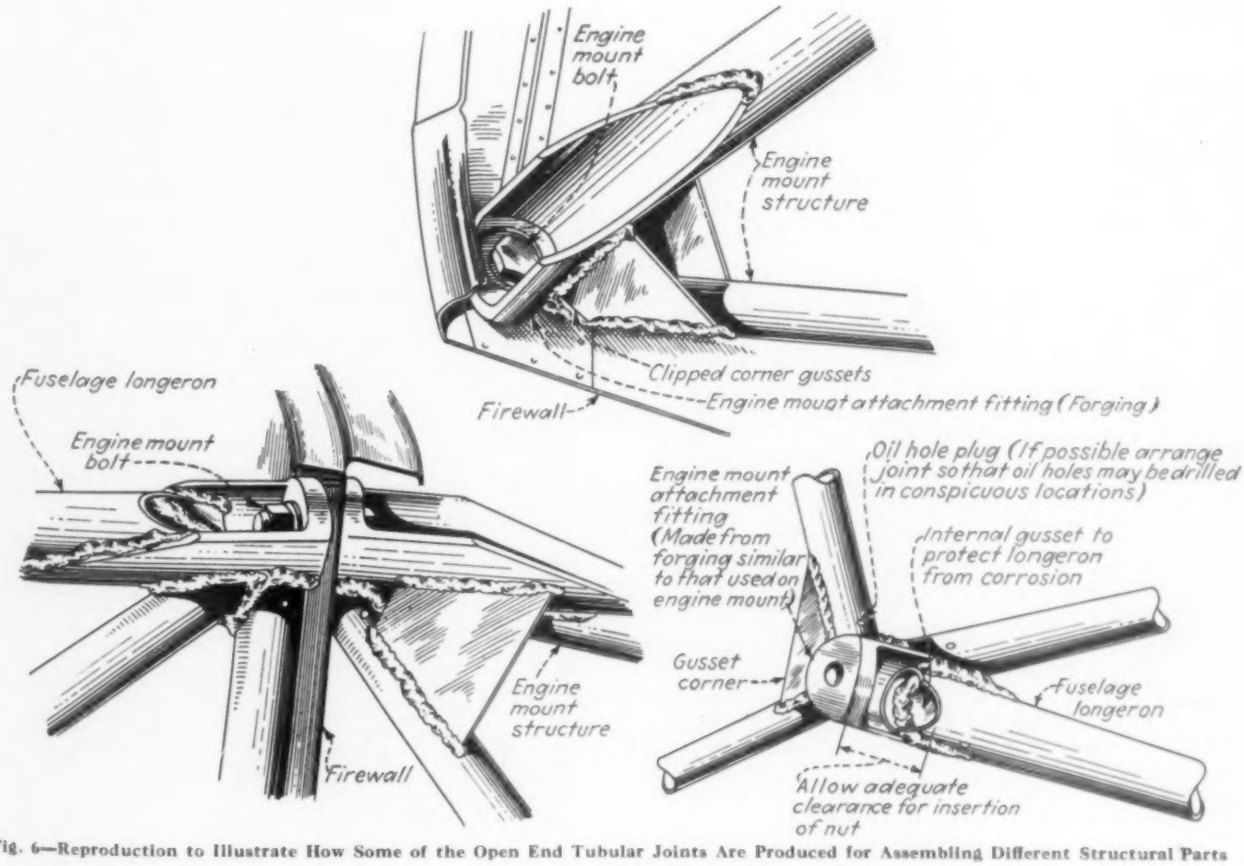
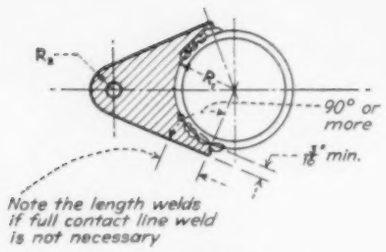
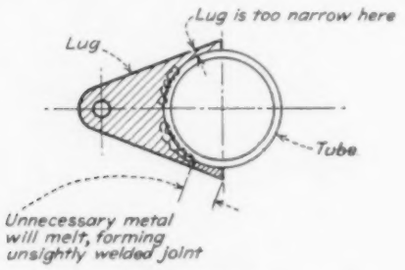

Engine mount bolt
Engine mount structure
Clipped corner gussets
Engine mount attachment fitting (Forging)
Firewall
Fuselage longeron
Engine mount bolt
Engine mount structure
Firewall
Engine mount attachment fitting (Made from forging similar to that used on engine mount)
Oil hole plug (If possible arrange joint so that oil holes may be drilled in conspicuous locations)
Internal gusset to protect longeron from corrosion
Gusset corner
Fuselage longeron
Allow adequate clearance for insertion of nut

Fig. 6—Reproduction to Illustrate How Some of the Open End Tubular Joints Are Produced for Assembling Different Structural Parts



CORRECT

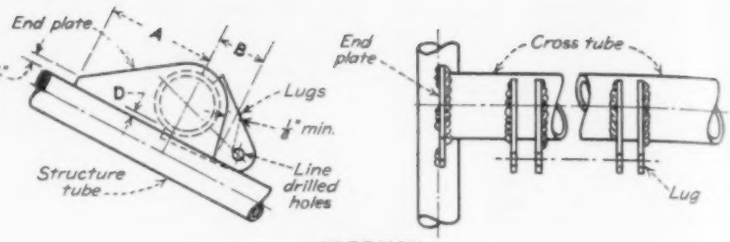
If a series of lugs are to be welded and line drilled it is advisable to make R_2 large enough to allow for weld distortion and yet maintain sufficient edge distance at hole. In most cases the distortion will not exceed ±1/16".



INCORRECT

Even if the welder avoided burning the narrow strip away, the value of the remaining base metal will not justify the care and skill required.

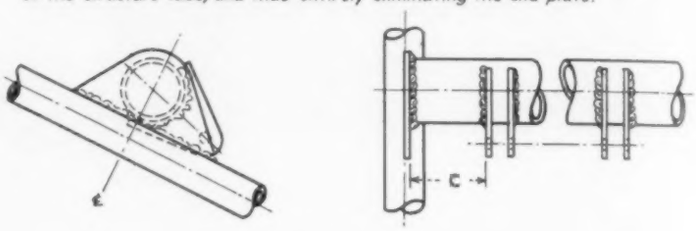
Fig. 8—Lug Design



CORRECT

*Tube, end plate and lugs are welded and drilled as one sub-assembly. The dimension **A** is greater than **B**, allowing sufficient length of plate to weld to the structure and also sufficient clearance for line-drilling after sub-assembly. Dimension **D** should be at least 1/16" to allow sealing the cross-tube by welding entirely around the tube at its junction with end-plate.*

This design can be improved by fitting the cross-tube on the centerline of the structure tube, and thus entirely eliminating the end-plate.

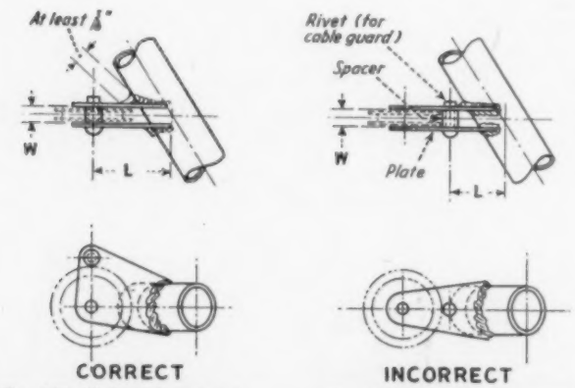


INCORRECT

*End-plate interferes with line-drilling of lugs, necessitating that this be done before plate is welded to tube, and necessitating an additional sub-assembly operation and jig. The second sub-assembly operation of welding plate to tube can be eliminated only if the dimension **C** is sufficient to permit using an off-set drill spindle, and this should not be considered for a production design.*

Fig. 9—Support Tube and Lugs

During the last war—only a little more than twenty years ago—nearly all planes were of wood and wire with top speeds of 90 to 150 miles per hour. Although Fokker built his Model D-7 with a steel tubular fuselage during the last war, it was not until after 1922 that the general use of our present chrome molybdenum steels came into the picture for tubular fuselage construction and tubular parts. A little more than ten years ago the so-called stressed skin or monocoque design was developed. Since that time the majority of planes for either national defense or transport have utilized this type of construction, with the result that two years ago an air corps representative went on record as stating that 85% of all structural materials for such planes was aluminum and its alloys. Even so, there was no research undertaken on the spot welding of aluminum until October 1940. I refer to the program now under way at Rensselaer Polytechnic Institute.



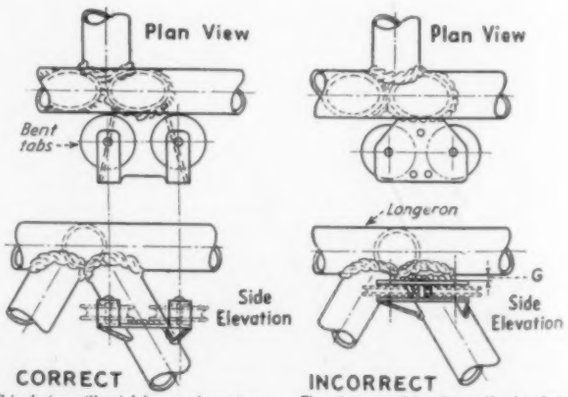
CORRECT

*The width **W** is not important in this design as all welding is done on the outside surfaces of the plates. The length **L** is also unimportant, as the rivet is at one side of the bracket, well away from the weld beads.*

INCORRECT

*The width **W** is entirely to narrow for weld access, and at the best it would only be possible to weld one plate on both sides, and then weld the second plate on the outside. The length **L** is too short, causing interference between rivet and weld bead.*

Fig. 10—Single Pulley Bracket



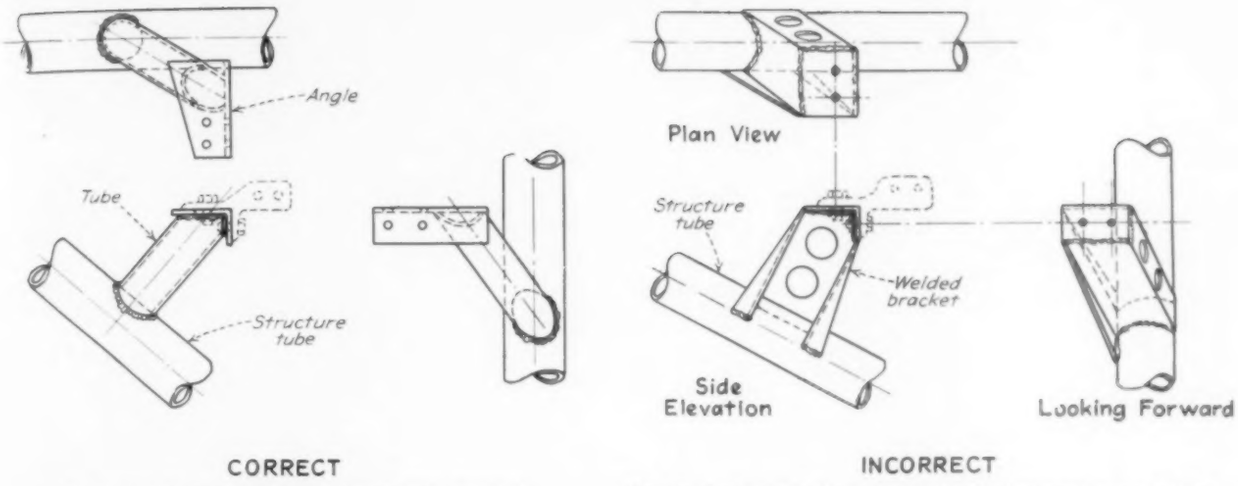
CORRECT

This design will weigh less, and requires only about half the amount of welding. The fabrication of the plate can be further simplified in the case of lightly stressed pulleys by spotwelding washers on the underside of the plate to provide adequate bearing area for cantilever axle bolts. This eliminates the bent-up tabs, and rivets and spacers are used to form cable guard pins.

INCORRECT

*The plates used for this pulley bracket require two blanking and one forming die for fabrication, and the actual welding is complicated by the gap **G** being too narrow for easy welding, as it necessitates a weld overlap at the upper plate.*

Fig. 11—Double Pulley Bracket



CORRECT

Angle may be straight-sheared and brake formed. Tube cuts are simple and easy to set-up. Welding operation is faster and more simple.

INCORRECT

This bracket is made from two pieces of sheet steel, one of which requires a blanking die and forming dies. Excessive weld time is required in joining the two parts at sub-assembly.

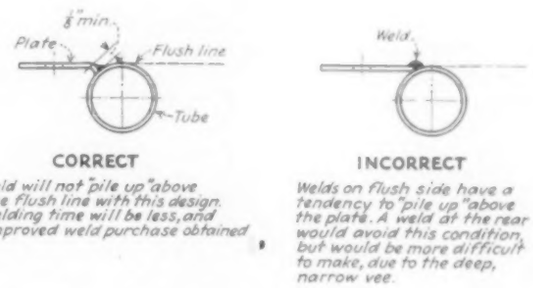
Fig. 12—Control Lever Bracket

Even though aluminum has so far proved most adaptable for the stressed skin design, no satisfactory substitute has been found for steel tubing in many important parts common in all aircraft—national defense, transport and small commercial planes. Also because of cost and availability, steel tubing is still the principal structural material for all of the so-called smaller commercial planes, trainers and certain designs used for observation, liaison, etc.

Even in the production of so-called aluminum planes, steel tubing is still an important factor as all of these use over 100 different sizes of steel tubing in engine mounts, landing gears and other highly stressed parts.

No general research on welding of steel for aircraft production has been done, although it is hoped such a program will be under way during this coming year. Most companies continued to use the oxyacetylene welding process, although arc welding is coming into use very fast and some companies on the Pacific Coast are using it almost exclusively. One company has developed, and is using, flash welding in the construction of engine mounts. With few exceptions, all-steel tubular structures are used in the as-welded condition, i.e., no heat treatment after welding. However, each plant has its own procedure, as there are no available references based on research to cover the production of parts of steel structures by welding.

For the benefit of those not in close touch with aircraft, it is important to emphasize that this is the first means of transportation where weight, or lack of it, is important. Most of us may have heard something of how the aircraft designer will fight to save even a pound. This



CORRECT

Weld will not "pile up" above the flush line with this design. Welding time will be less, and improved weld purchase obtained

INCORRECT

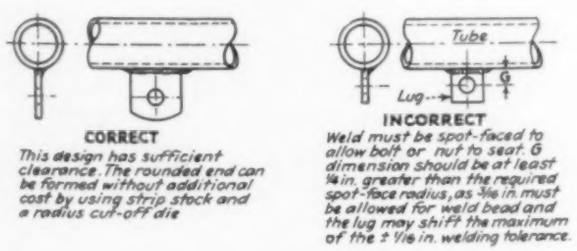
Welds on flush side have a tendency to "pile up" above the plate. A weld at the rear would avoid this condition, but would be more difficult to make, due to the deep, narrow vee.

Fig. 14—Mounting Lug—Tangent to Tube

pound in a structure may mean four to five pounds for other parts to support the added weight, plus additional gasoline, larger tanks, etc., if the plane is to meet its minimum performance requirements.

Under such conditions it is only natural that the aircraft designer will utilize the thinnest possible gages, reduce fittings, and any other means work to the end of obtaining reduced weight. Without procedure control the production prints go into the shop theoretically okay, but frequently causing many a headache to the production group.

Of course, a few of the older and larger companies have recently taken steps to correct this condition and have now set up a procedure requiring close personal contact between the designing group and the production group,



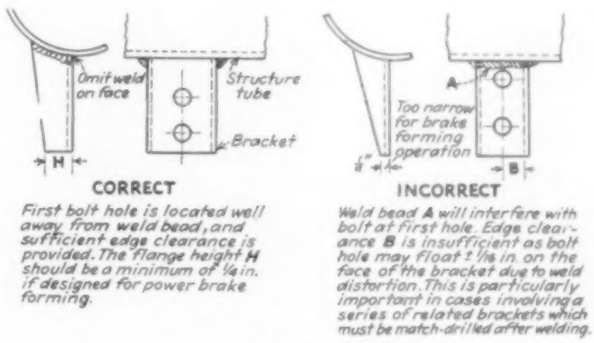
CORRECT

This design has sufficient clearance. The rounded end can be formed without additional cost by using strip stock and a radius cut-off die

INCORRECT

Weld must be spot-faced to allow bolt or nut to seat. G dimension should be at least ¼ in. greater than the required spot-face radius, as 3/16 in. must be allowed for weld bead and the lug may shift the maximum of the ± 1/16 in. welding tolerance.

Fig. 13—Mounting Lug, Radial to Tube



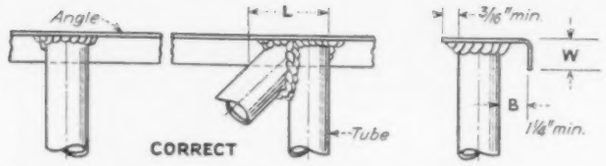
CORRECT

First bolt hole is located well away from weld bead, and sufficient edge clearance is provided. The flange height H should be a minimum of ¼ in. if designed for power brake forming.

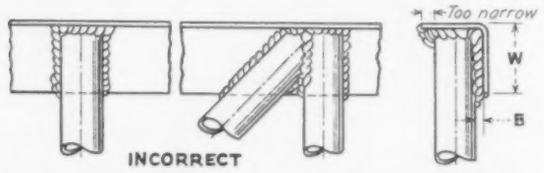
INCORRECT

Weld bead A will interfere with bolt at first hole. Edge clearance B is insufficient as bolt hole may float ± 1/16 in. on the face of the bracket due to weld distortion. This is particularly important in cases involving a series of related brackets which must be match-drilled after welding.

Fig. 15—Mounting Bracket



This design saves 50 percent of welding time required for the "incorrect" design, and will have less distortion from welding. Dimension **B** should be approximately equal to flange width **W** unless **B** is 5/8 in. or more. The dimension **L** is a factor of weld accessability, since width **W** should decrease as **L** increases, and vice versa.



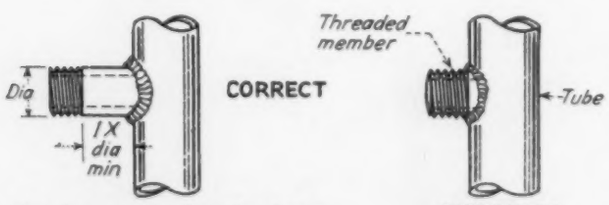
Narrow edge burns away easily, requires extreme care during welding. The dimension **B** is too narrow to allow seal-welding the tubes without "piling" the weld bead, which increases welding time, slows production and increases warpage. If design will not permit a minimum **B** dimension of 5/8 in., and where **W** must be 5/8 in. or more, it is best to eliminate gap **B** and fit tube snug to angle flange

Fig. 16—Shelf or Rail Welded to Tubing

and in some cases a product analysis group is functioning. These men, of course, must be familiar with the problems involved and have the authority to make decisions. Before any design is released to the shop, it must be approved by all members of this group. There may be separate groups for each particular field, such as structures, interiors and the like, but the best arrangement is one wherein one product analysis group passes upon every part of the airplane. In case of doubt or difference of opinion, two or more test parts are actually produced, cost estimates made, and the final decision based on the most satisfactory method, with all factors considered.

In most shop operations, particularly welding, process standards are issued covering in minute detail the sequence of operations and the type of welding to be used, as well as type of inspection. These details, of course, also cover jigging, tack welding, preheating, if any, and detailed sequence for each joint.

The product analysis group's main function is to analyze each new design, whether it be detail part, assembly or complete airplane, in the light of its adaptability to economical mass production—prior to the release of the design. The men forming this group are thoroughly familiar with all available production processes and the mechanical limitations of each, and are able to determine by inspection and investigation the



2X dia permits threading before welding without danger of thread distortion during welding. Nipple may be either threaded from tube or bar stock - providing that tube has a heavy wall, or that bar stock does not exceed 7/8 in dia., unless rough drilled before welding

Threaded part will distort if threading is done before welding; short length of nipple makes threading after welding impractical

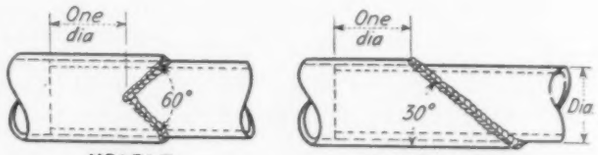
Fig. 17—Boss Welded to Tube

practicability of producing a given design with the production facilities available. Designs which are unsound from the standpoint of economical production are reviewed with their designers to develop alternate designs that can be produced satisfactorily and still accomplish the design function.

The factors involved in product analysis of welded steel tubular structures are comparatively few, and principally involve (1) welding accessibility and (2) balanced joints. These two factors should be kept in mind at all times by every designer working with welded structures, and, if intelligently applied, will go a long way toward insuring practical production designs.

The wall thicknesses and sheet gages available for major fittings and joints are large enough to minimize balanced joint considerations. But most detail fittings are thin sheet metal brackets, clips or lugs welded to comparatively heavy wall tubing or vice versa. To complicate their design further, the space available for many of these detail fittings is limited and considerable ingenuity is required to develop fittings which will permit adequate clearances for rapid production with standard welding equipment.

In the illustrations following are shown some of the more common design errors with welded steel structures, which originate from ignorance or neglect of the basic



Double cut necessary on outside tube Requires more torch manipulation than other type because of two corners

Only one cut necessary on tube cut from mill stock easily welded

Fig. 18—Welded Tube Joints

factors of balanced joints and welding accessibility, and which can be avoided by Management Control of Design and Welding, coupled with intelligent Product Analysis.

Even though it may not have a direct part in this subject, we are going to take advantage of this opportunity to add a few thoughts on what we believe can be expected by research on the use of steel for aircraft design and manufacture.

1. We will develop steels having much higher physical values.

2. Not only will our welding technique be improved, but I believe a method can be developed whereby many parts of a structure will be placed in a jig, possibly under pressure, the current turned on and the complete welding process effected in a split second.

3. Also we will develop some non-destructive method for determining the quality of a weld. Such a test has been in use by the boiler industry for many years.

4. It will be shown that some form of heat treatment on all welded joints will be standard practice rather than the exception. Why use a fairly expensive alloy steel at relatively low physical values and further reduce these values by allowing only 80% of the ultimate tensile strength on all welded joints? The result today is a tensile strength easily met by a medium carbon steel.

Automotive Welding*

By S. M. Spice†, Vaughan Fegley‡ and L. M. Skidmore§

THIS paper is definitely not of a highly technical nature, but rather a simple, straight-forward story of what is being done today in our plants and an attempt to indicate the future trends for the different forms of welding.

This age we live in is known as the age of metals; it is fast becoming the age of welded metals. Structures ranging from thousands of tons to fractions of ounces are being welded today, and then are proving their worth in an age that is hard to please. Greater than ever before is the strength per unit of weight now obtained.

The economic advantages of welding are to be seen everywhere. In general, welding is much faster than the old mechanical methods of attachment. Sections may be reduced and structures may be fabricated in smaller units which may be handled and shipped more economically. Raw materials are conserved by reduction of weight and elimination of much waste. Worn parts are built up again, often to give better service than originally, Replacements are cut down, and down-time for repair is reduced to an important degree.

All this means savings in dollars and cents that are incalculable as a whole, and it gives the buying public far more for their money than ever before.

Because of all this we travel faster, accomplish more in a shorter length of time, and in general enjoy a better and more exciting life.

This brings us to the automotive industry, where the growth of welding has been at least as phenomenal as in the other metal industries. Again the economic advantages are recognized and the possibilities probably exceed the applications.

Designers, now thinking in terms of welding, no longer have to be pushed into a welded design. As a matter of fact, the shoe is on the other foot, for designers are pushing the welding engineers around. This in itself is a healthy sign for the future.

Of the various forms of welding, it is an unquestionable fact that resistance welding has made the greatest advancement in automotive production work in recent years. Why? Because new developments in resistance welders have opened up great new vistas of possibilities for the present and the future.

Resistance welder manufacturers are denied the full glory of this statement because the stride set recently by resistance welding shares its success with the associated equipment; namely, various special alloy electrodes and controls such as the synchronous timers, phase-shift heat controls, ignitron contactors, etc.

We are making welds today that not long ago were economically and practically impossible. Many ferrous and non-ferrous metals and alloys that were formerly not considered practical to weld now can be safely welded. And more of them will be welded in the future. Medium and high carbon steels and alloys may be welded with safety, a thing we were afraid to do not long ago. Most of the credit goes to synchronous timing, interrupted timing, phase-shift control in single and multiple stages, plus electronic contactors, all operating with repeatable accuracy.

The welding electrodes and tips developed by the welding electrode manufacturer have played no small part in the brilliant success of resistance welding in industry. Greatly increased life of welding tips over that of the old common copper tips is a well-established and known accomplishment in the field today. Many of the now operating welding jobs would be an impossibility from an electrode maintenance and replacement cost standpoint were it not for the special alloys developed by the men in the electrode industries.

Welder manufacturers are taking advantage of these better controls and alloys, and must continue to do so. There is a big field for improvement in the welding machines themselves. The machines must be more accurate, friction and inertia weight must be reduced, tooling and gaging must be improved and many other refinements must be included all of which the automotive manufacturer will applaud.

An example of this need has been developed at one of the AC plants and is now in production on a defense order.

It was decided that, in fabricating the end electrode to an aircraft spark plug shell, resistance welding was the method to be used, but the location of this end electrode had to be very definite and required precision welding. A machine was designed by one of the leading welding machine manufacturers. It was equipped with a complete synchronous control timer and ignitron contactor. The design was approved after a few changes resulting from exhaustive experimentations on the part of both the machine manufacturer and customer. The machine was then built and, upon completion, again after tireless efforts of several weeks' experimenting, more changes were made. All in all, a period of approximately six months transpired, but today this end electrode is being resistance welded to the shell on a production basis at the rate of five hundred per hour, controlling the concentricity of the electrode to the shell within 0.005 of an inch, the sinkage of the weld within 0.010 of an inch and the weld in itself a one hundred per cent bond. Incidentally, a very important fact which has not been mentioned is that the shell is a ferrous material and the end electrode non-ferrous.

Automotive parts, except for a few notable exceptions, are much more economically resistance welded. This is true because of the requirements of high production and of the comparatively small size of the parts. Capital investment is higher in this form of welding than in all other forms, but the many times greater output more than repays the user.

* Presented at the Annual Meeting, A. W. S., Philadelphia, Pa., Oct. 20 to 24, 1941.

† Buick Motor Division.
‡ AC Spark Plug Division.
§ General Motors Institute.

Arc and gas welding, just as important to the automotive industry as resistance welding, find their best application not in production but in machine structure fabrication, machine repair, maintenance, hard surfacing, material salvage and others. More will be said about this later.

Now a word about the copper alloys. All of you are acquainted with the advantages of these alloy electrode materials, but it might be well to cite a common example. For two years, at the AC plant, flash-welding-electrode dies machined from copper were used on a job welding a one-half inch diameter fitting to a one-half inch diameter shaft, both parts of SAE 1020 steel. The volume of production was not too great, hence electrode maintenance was not a problem. Suddenly, however, production schedules on the part took a very sharp rise, and machine down-time for electrode replacement became a very serious problem. Various alloys were tried, and in most cases longer life was realized, but results were still not as favorable as desired. After about three months of experimenting, a tungsten alloy insert with "Class II" alloy backing made it possible for a single set of electrodes to be used in the machine for a period of time that was staggering compared to the older type copper ones. Because weld spatter did not adhere to the new electrodes, the upper steel clamping members were changed to the new material also. Thus additional savings were made in down-time.

One phase of the field has a very definite need for a longer life electrode material and that is for use in hot riveting with a resistance welding machine. The resistance hot riveting system is being used on one of the operations fabricating a machine gun assembly. The resulting job is a very good one, being not only faster but very satisfactory and less costly to produce than a cold riveting job. Although the present electrode life is not too favorable, the engineers of the welding electrode manufacturers are working to improve it.

Judicious use of copper alloy electrode materials is imperative. All too often the harder alloys are recommended for jobs where the softer ones will give longer life and much more trouble-free service. It must be remembered that the harder alloys are much harder than the majority of steel parts being welded, and that the ability of the electrodes to conform to the steel parts to be welded is very limited. This fact, plus the low electrical conductivity of these electrodes, makes localized burning or sticking a more-than-average possibility. At Buick the lower hardness alloys are more often used except where small area inserts are used for restricted contact.

Another device much in use at Buick is the copper liner method, where, on parts of non-uniform surface, the medium hardness alloy electrodes are covered with an annealed sheet copper liner. This liner conforms to the part and lasts a surprisingly long time. Replacement is a matter of minutes, and the cost is low. Furthermore, for heavy welding it is the practice to buy two sets of electrodes for a given job on a new welder. They very often last out the model year, and it is not unusual for one set to do the same.

May it be most emphatically stated that good results are never obtained without adequate and intelligently applied water cooling. Furthermore, such results can only be obtained with clean surfaces on the parts to be welded.

Low impedance power distribution systems with excellent voltage regulation are now available but are rarely seen in the welder users' shops. An old style feeder system takes all the "bark" out of a welder, leaving nothing but a "groan" to be heard.

Let us now look at automotive welding as it is today in the writers' plants.

The need for better distribution systems is being recognized. One new Buick factory, now a year old, uses a complete single-phase system of parallel bus separated only by two thin strips of woven glass insulation, fed at intervals by transformer banks. Separate concentric cables take off from this bus to individual welder controls. Several thousand kva. of name plate rating connected load are fed from this system. A number of 600 and 750-kva. welders are in operation without interference either with each other or with other and more delicate welder operations. Of greater importance is the fact that precision rear axle gear cutters on the regular three-phase system in this plant are not affected.

Here are some of the operations fed by this high-efficiency distribution system.

Torque tubes are completely resistance welded. The tubing itself is $3^3/_8$-in. diameter by $^5/_{32}$-in. wall, and is butt seam-welded continuously in a large mill from coiled strip. A flash welder preceding the mill welds the coils end on end into one continuous length. Formerly the heat on the mill was controlled by a tap switch with 64 points of heat. When an adjustment in heat was made, the mill had to be stopped, resulting in lost time and a weld skip. All this has been done away with by means of electronic controls. Ignition tubes and a phase shift now give stepless heat control without stopping the mill and without weld skips, all controlled by a small dial beneath the hand of the operator. Weld quality has measurably improved with this installation.

One end of the tube is necked down cold in an upsetter in two passes. The diameter is reduced from $3^3/_8$ in. to 2 in., and the wall thickness at the neck increased from $^5/_{32}$ in. to $^1/_4$ in. Welds withstand this very heavy cold reduction with no loss. Large and small flanges are made by pressing steel balls through holes in blanks of $^7/_{16}$ in. and $^9/_{16}$ in. thickness extruding collars that match the tube ends. These flanges are then simultaneously flash welded to the tube ends in one double-end machine of 400-kva. total. Subsequently a heavy stamped bracket $^3/_8$ in. thick is projection welded to the outside of the tube. There are four $^1/_2$-in. diameter projections which give a welded shear strength of 35,000 to 40,000 lb. No internal electrode can be used, but pulsation timing on a 600-kva. machine gives uniform results. Incidentally, this pulsation job is in its third year of operation. The torque tube has high strength and stiffness because of its cold work hardness which has not been affected by the welding operations.

The rear axle housings have all spring seats and other brackets welded by the projection method. Some are edgewelds, others flat, some are pulsation, others are straight time and all are done on hydraulic machines. The welders are 600 and 750-kva. rating, the larger being double head, single transformer automatic sequence operated. The latest of these has shear loaded rubber sleeve cushions just above the platens to reduce inertia weight and give better follow-up. Firing in this case is by microswitch on the cushion travel.

Propeller shafts are both assembled and seam-welded in the same machine in one automatic operation. Here full hard-cold rolled, electrically butt seam-welded tubing is circular seam-welded to medium carbon manganese alloy heat-treated ends completely machined.

The machine is loaded with the three parts, and at the push of a start button hydraulically presses the ends into the tube directly under the seam-welding wheels. The wheels then contact the tube ends and start to rotate and weld. During the welding cycle some end pressure is kept on the shaft to keep it straight and to length.

After complete rotation of the shaft the machine automatically opens up for removal of assembly which is now ready for assembly into the rear axle with only a slight snagging operation to remove possible loose particles of metal. The welding portion of this machine consists of two 200-kva. seam welders in one frame but with separate dual seam panels of the rotating-disk and pin-triggered electronic type. This machine is in its third year of operation, during which time much research and development have taken place.

In the production year just completed two brackets of low-carbon steel were simultaneously projection welded to a 0.45 carbon medium sulphur finish machined cold-rolled "D" section shaft, without damaging the physical properties of the assembly. This shaft was cold-rolled to a definite hardness, and the weld thumb nail areas were kept very closely to that same hardness by phase-shift heat-control steps which counterbalanced the mass quench effect of the cold shaft. The welder had a 300-kva. transformer for each head, both controlled from the one phase-shift and ignitron set-up. Weld time was 45 cycles at about 55% phase shift followed, without current interruption, by 18 to 20% level for 10 seconds. This latter time element was important for uniform and narrow range hardness control. Lubricated fabric bushings on the shaft ends within an inch of the welds were not affected by the operation. Shafts were removed from the welder to a tank of soluble oil and water coolant which prevented further diffusion of the heat. Production was maintained at three assemblies per minute. Hardness in the weld area would normally have been 50 to 60 Rockwell "C" instead of the 20 to 25 obtained, and the shaft would have snapped like a match stick under load.

Many other welding or allied jobs could be described, if time permitted, such as large electrically riveted pins upset on both head and pin sides of the bracket. The rivet hole is hexagonal for torsional strength, and the rivet fills this hole so tightly that the hex punch marks are impressed into the rivet body. Also in the new multiple spot operations on front fenders, 52 welds are made in only two sequences by means of multiple secondary transformers. In these welders, three sides are completely open without obstruction for loading and unloading purposes. Total machine cycle is but five seconds.

At AC Spark Plug Division a similar high-efficiency power distribution system is in use in the new plants.

The current scarcity of machine tools has been a stimulus to the welding of high-speed steel drills, reamers and other cutting tools to the cheaper and not quite so scarce cold-rolled steel shanks. This is not a new idea by far, but is being practiced more extensively now than ever before and with great success. It is one of the many steps being taken by the manufacturers to conserve the now more precious grades of tool steel.

At AC one very good example of machine tool welding is the fabrication of the high-speed steel gun drills to their shanks. These shanks, made of a special seamless steel tubing, are approximately four feet long. The $^{3}/_{8}$-in. diameter high-speed steel tip also has a hole through it to facilitate the flow of oil coolant coming through the shank to its cutting end.

First attempts to resistance weld were made by the flash butt method. The resulting weld was satisfactory, but the flash created during the burn-off period had clogged the oil hole. This condition, of course, could not be tolerated, so a better method had to be developed. Pulsation butt welding was tried. Even the first welds made were quite promising and after a few adjustments and more trials were made, very satisfactory welds resulted. Tests on several pieces welded by this system revealed the weld to be as strong as either the shank or the drill end.

These and many other welding operations show what is being done, and point the way to what can be done by the exercise of mechanical ingenuity plus the controls mentioned earlier.

There are, of course, some parts of the automobile where resistance welding does not have a clear field. Some parts do not lend themselves economically. At the AC plant an automatic arc-welding head was recently installed on a particular job. Its output more than equaled that of four skilled operators previously used, and a better quality also resulted. Production volume prohibited the purchase of a special type resistance welder that would have been required to produce the job.

The branch exhaust pipe for two carburetor motors of Buick cars is another good example. These pipes could be successfully resistance welded, but the cost of preparing the joints is relatively high and capital investment is also high. When cost estimates are summed up, the two methods, arc and resistance welding, are about equal; therefore we chose the method with the least capital investment, i.e., arc welding. An A.C.-D.C. welding rod of good characteristics is used in conjunction with A.C. welding units. The A.C. arc method was chosen because the jigs required for accuracy were bulky and might cause arc blow with a D.C. arc. Our judgment was proved accurate in this case. All joints are pressure tested, and comparatively few are rejected for leaks.

Arc welding of automotive parts must be used judiciously. In many parts we depend upon heat-treated or cold-work strength. Since the heat of arc welding affects relatively large areas, fatigue failure may occur at these points unless careful study has gone into the job beforehand.

Examples of arc-welded parts are rear axle housings and frames. In the former, approximately 80 inches of weld is a natural automatic job. In this particular case a carbon arc with no extraneous filler metal is used. In frames, no long welds are needed, but rather large numbers of short welds, where a skilled operator can jump from weld to weld without breaking his arc.

Automotive bodies of today contain all three major forms of welding: resistance, arc and gas. Each has its place, depending upon accessibility, surface or strength. Of the three, resistance welding leads the field.

Repair of productive gray iron castings is a fairly large field for both arc and gas welding. Small defects are repaired at no sacrifice of casting quality or strength, and thousands of dollars worth of castings are saved from the scrap bin. This is standard practice in any automotive foundry.

Castings repaired at the foundry are, wherever possible, gas welded in an automatic preheating and annealing cycle which makes volume and quality possible.

Castings repaired in the machine shops after partial machining are usually arc welded. This practice is dictated by the distortions that would occur were the preheat, gas-weld and method used. Such distortions cannot be tolerated in partly machined castings. Arc welding of gray iron castings is successful only where good judgment is used in the materials employed, the type of defect repaired and the nature and shape of the part. The skill of the welder is of paramount importance.

The undisputed fields of arc and gas welding are in the maintenance and machine repair divisions. Foundries are ideal places for this type of repair. Handling equipment and all types of machinery used in such a

place take a terrible beating from the abrasive action of molding and core sand, from the pounding of castings being handled and cleaned and from the moving of hundreds of tons of molten metal in ladles. Sand handling sheet metal ducts, etc., are patched and patched again. Sand beaters and plows are hard surfaced over and over. Conveyer flights are repaired and built up as also are monorails and other moving equipment.

The foundry is a field all its own, but not far behind are the forge and sheet metal shops. Forging and trimming dies can be built up by hard facing to give much additional life. Sheet metal draw and blanking dies are built up and surfaced over and over again. Tremendous impacts and pressures are hard on the hammers and presses used in this work. Broken frames may be welded or brazed, saving much money in replacements and downtime. Temporary welds may keep a job going until new parts can be obtained. All the smaller maintenance and machine repair points are making temporary or permanent weld repairs constantly.

When a part breaks or wears out the first thought in all these places is *can it be welded*. More often than not, welding saves the day. What a turmoil we would be in if, overnight, welding became a lost art. So may we repeat, this is definitely the age of welded metal, every day more so.

What the future brings will come only through the best efforts of all of us, and particularly through the efforts of those of us who are assembled here this week.

Here are some of the developments that are definitely on the way, and those that we as yet are too blind to see and yet for which there is a crying need. We have ignored or failed to mention some of the newer developments which as yet do not apply to the automotive industry:

1. A method of butt welding which has the good fusion properties of butt flash welding but without the large burn-off and upset that so often prohibit its use because of the cleaning problem.
2. Welding hardenable steels to definitely controlled hardnesses, to retain the physical properties inherent in these steels for the purposes used.
3. Improved machines for resistance heating and forming for upsetting and other hot forming operations. Also resistance heating for local heat treating operations.
4. Improved mechanisms for close tolerance welding.
5. Improved mechanisms for high-speed loading and unloading.
6. The metallurgist must increasingly share responsibility with the electrical and mechanical engineers, where welding is concerned, if the final result is to be more satisfactory. Resistance welding is an electro-mechanical operation in which the final result is a metallurgical one.
7. Electrode and tool and gage design are probably the weakest spots in resistance welding today. Only slightly better are the pressure mechanisms.

The welding industries of today are having the growing pains that attend the growth of all big business. The users are sharing much of the pain with them; this is particularly true of resistance welding.

How to determine good welds from bad is a problem. At this stage, the best answer is the use of better equipment plus a more understanding maintenance plus percentage destructive testing.

We have tried to show present advances, and from these indicate future trends plus the needs of the automotive industry.

The use of welding will grow in spite of all of us, but it will grow much more painlessly when the problem of both user and manufacturer are better understood.

One of the greatest contributions any of us can make to the future of welding is to make the best thought and experience of the men who are doing the job today available to the young men who are to come along in the field, and those who are training in our various schools, from the standpoint of both engineering and skills.

By correlating these practices and ideas of modern procedures with the fundamental aspects of the subject, we may present them in a manner that will be of real practical value to the man and to the field of welding in general.

We feel that cooperative training offers a great advantage in this respect because the man may get at first hand the practices and developments that are going on daily, in addition to the related theory in school.

In lieu of the cooperative plan of training, it is highly desirable to have the assistance of the persons who are known in the field and who in a great measure have been responsible for our modern developments.

The papers and discussions presented at these meetings and the meetings of our local chapters are a decided aid to the training field in keeping us abreast of modern practices.

It may be of particular interest to you gentlemen to know that, during the past school year, more than 51,000 man-hours of instruction were given in the various fields of welding at General Motors Institute. Included in this instruction were arc, acetylene and resistance welding, as well as electronics and controlling devices. An increase of at least thirty per cent is expected for this year because of the ever-increasing importance of welding in national defense.

BOUND VOLUME JOURNAL

The American Welding Society has made arrangements for members who wish to have their Journals for 1941 bound in attractive, imitation black leather covers, to do so by sending copies of the twelve issues to Russell-Rutter Company, Thirty-Third Street and Eighth Avenue, New York, N. Y., Att. Mr. Russell Lauben, Jr. A special reduced rate has been arranged at $2.50 per volume providing the issues of the Journal are sent to the binder on or before Jan. 15, 1942. The bill for the binding and return postage will be sent direct from the Society's office.

Demand Improvement for Resistance Welding Loads*

By H. R. Crago†

THE subject of power supply for resistance welding loads and means for reducing peak demands has, in the past, been one of primary interest to the power distribution engineer only. Today it is of equal importance to both the user and the manufacturer of resistance welding equipment. It is of interest to the user not only because modern welding technique demands an adequate, well-regulated power supply but, of perhaps equal importance, because many power companies have placed limitations on allowable welder loads and have written into their rate structures severe penalties where these values are exceeded. Any additional power costs resulting from the penalties must necessarily be factored into the cost of the welded product. It is of interest to the manufacturer of resistance welding machines because his responsibility, far from ending with the efficient design and production of the machine, ends only after the machine is connected to an adequate power circuit and is doing the job for which it was intended. All too frequently the power supply has been left to chance with resulting dissatisfaction to all concerned.

Since the art of resistance welding is not a new one we might logically ask what present-day factors have brought about the necessity for demand limitation. In the early days of resistance welding when machines were small and few in number the percentage of total plant load represented by welders was so small that the intermittent, low power factor, single-phase welder load did not represent any appreciable disturbance on either the primary power system or the secondary plant distribution system. In those few cases where complaints were received due to line disturbance the power company made the necessary changes and absorbed the cost as a necessary service to a good power customer.

As welding machines increased in both size and number and the demand represented by the welder load frequently exceeded by many times the normal steady plant load, complaints due to light flicker and impaired performance of other electrical equipment became more frequent. The result was that the power companies were frequently faced with the necessity of strengthening their power system and segregation of lighting circuits at a cost disproportionate to the revenue derived from the welding load. Rate structure changes became inevitable. Just as the power companies were affected so also were many plants affected because large welding machines, the kva. demand for which was frequently not appreciated at the time of installation, were connected to inadequate plant distribution systems with the result that line drop was so severe as to seriously impair the welding process and in some cases prevent operation of the machine entirely.

With the additional power demands represented by the defense program, distribution lines are being loaded to capacity and in many cases small isolated plants served by long "shoe-string" lines are accepting defense contracts requiring large welding machines so that the subject of power demand limitation is a timely one.

Obviously, therefore, the power supply to which a resistance welder is to be connected and the power requirements of the machine should be subjected to close study at the time the machine is ordered.

It is the purpose of this paper to cover some of the available means for reducing the kva. demand for conventional resistance welders and to compare the advantages and economies of the various systems. In this discussion it is not proposed to cover the so-called energy storage welders since this subject has been covered or will be covered by other speakers. Neither will this paper go into the details of resistance welder design.

Since the early days of the electrical industry engineers have tried to find a way to distribute a single-phase load over the three-phase of a conventional power system by means of transformers alone. Many schemes have been proposed and investigated but none of the combinations gives better results than can be obtained by simply connecting the load across one phase. This fact is mentioned here because the question is frequently asked in regard to resistance welder loads where such a system of transformation would be of inestimable value in reducing line demand. It is interesting to note that Dr. Steinmetz explained to A. I. E. E. in 1892 the basic reason for failure to accomplish this transformation as follows: Single-phase power changes from a maximum to zero and back to maximum every half-cycle while polyphase power is delivered at a constant rate. Therefore, any system capable of transforming from balanced polyphase current to single-phase current must be capable of storing energy during the interval of time when power delivered to the single-phase side is less than the power received from the three-phase side.

Perhaps the oldest and most universally used method for reducing line demand is to interpose a motor generator set between the welder and the three-phase power supply. Such a set consists of a single phase a.c. generator with necessary exciter driven by a polyphase motor of either the induction or synchronous type. The motor takes power from the polyphase system and delivers it through the generator single phase. This system offers the twofold advantage of distributing the single-phase load over the polyphase supply and at the same time improving the power factor from the characteristic low value of the welding machine to the relatively high value of the motor load. A motor generator set of this type is relatively expensive in relation to the equivalent continuous power requirements of the load because of the necessity for building the generator on the basis of voltage regulation rather than on the basis of heating. The motor can generally be much smaller than

* Presented at the Annual Meeting, A. W. S., Philadelphia, Pa., Oct. 20 to 24, 1941.

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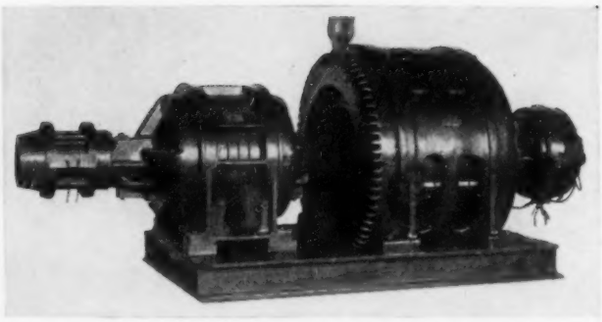


Fig. 1—Welding Phase-Changer Set—200 Kw

the generator since it can be applied on a basis of its ability to carry the heavy load for short periods. A typical set for this service is shown in Fig. 1. The small generator mounted on the end-shield of the motor is used for supplying control power to electronic synchronous timer equipment.

In order that some idea might be had of the improvement in demand using a motor generator let us consider as an example a welding machine which normally has a demand of 700 amperes from a 440-volt line at a power factor of 35%. Interposing a motor generator set will reduce the line demand to approximately 275 amperes per phase at a power factor of approximately 75%, assuming a generator efficiency of 85% and motor efficiency of 80%. Actually the line demand would be somewhat less than this in the case of a spot welder load because it would be possible to design the set such that the motor tends to slow down as the load is imposed on the generator, thus allowing the inertia of the motor and generator to supply a part of the power required by the weld. In some cases a flywheel can be used to increase the inertia but in general this additional expense cannot be justified. Using the inertia of the set to absorb part of the welder demand is only practicable in the case of spot welds of short duration and where there is sufficient time between welds to permit the speed of the set to be restored to normal.

While the motor generator set offers a way of reducing line demands this reduction is obtained at the expense of the continuous running light losses of the set. In the case of the example cited these losses will be between 10 kw. and 12 kw. The cost of this continuous load must be considered in any saving expected from the use of a motor generator.

Where a continuous plant load of low power factor exists a motor generator with synchronous motor drive for supplying the welder load can be used, taking advantage of the power factor correcting characteristics of the synchronous motor to improve the over-all power factor of the plant. In such an application the improvement in general plant load will more than compensate for the running light losses of the set.

When more than one welder is in use a single motor generator can be used to supply power to the group by interlocking the welders so that only one machine can be connected to the generator at once. In this case the size of the motor generator is determined by the demand of the largest welder.

Capacitors

A second method for reducing the line demand of resitance welders is the use of series capacitors for power factor correction. Since the power factor of the larger sizes of welders is generally between 25% and 40%, correction of the power factor to unity affects a reduction in line demand of 60 to 75%. The lower the power factor of the welder the greater will be the per cent reduction. In the case previously cited where the demand was 700 amperes at 35% power factor, the demand can be reduced to 245 amperes by correcting the power factor to unity. The use of series capacitors with resistance welders has now proved successful in a sufficiently large number of installations to justify the prediction that a more widespread use in the resistance welding field awaits only a fuller appreciation of the advantages offered and greater familiarity with their application.

Figure 2 shows a large series capacitor installation. It will be noted that the capacitors have been mounted on a balcony, thus utilizing none of the floor space surrounding the machine.

Relative Costs

It is impossible to make a general statement covering the cases where corrective measures at the load are more advantageous to all concerned than line and substation reinforcement since the economics of each individual case must be the governing factor. It is possible to say, however, that line and substation reinforcement, particularly in the case of underground networks, is generally an expensive expedient and even where only a part of the cost is assessed against the user it is frequently less expensive to apply corrective measures at the load.

Several recent cases, where line reinforcement was considered necessary because of resistance welder loads, will give some idea of cost involved. A 220-volt spot welder with a demand of 700 amperes fed from an underground network would have necessitated an expenditure of approximately $20,000.* Another case of a machine having a demand of 300 kva. would have required a new

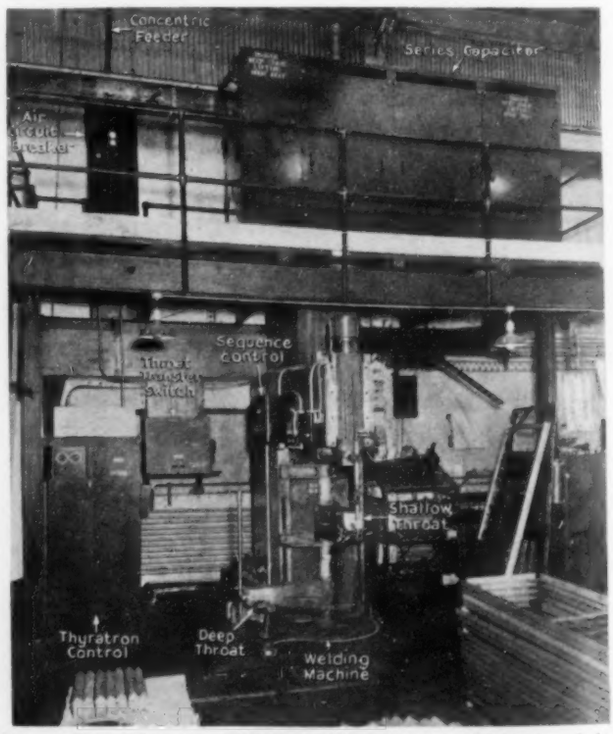


Fig. 2—Large Pulsation Resistance Spot-Welding Machine and Associated Control, with Series Capacitor for Power-Factor Correction Max. Welding-Machine Demand Approx. 2500 Kva. Max. Line Demand Approx. 800 Kva.

line and substation facilities costing $13,000 to eliminate a bad case of light flicker. While these cases are not necessarily typical they are cited as a basis of comparison against the cost of motor generator or capacitor correction.

In the case of the first machine cited above a series capacitor equipment complete with auto-transformer for use between the line and welder has a price of less than 10% of the cost of line reinforcement and in the case of the 300-kva. demand machine a series capacitor equipment represents a price of less than 20% of cost of line and substation reinforcement. Motor generator sets would have been somewhat more expensive than series capacitors but less than the method originally contemplated.

Figure 3 shows a price comparison between series capacitor equipment and motor generator equipment for demands from 100 to 850 kva. against an arbitrary vertical scale. It will be noted that the price of series capacitors is approximately 35% of the price of motor generator for the same kva. demand. In making this comparison the motor generator prices include an auxiliary generator for control power supply and the capacitor prices include an auto-transformer for use between the line and the welding transformer.

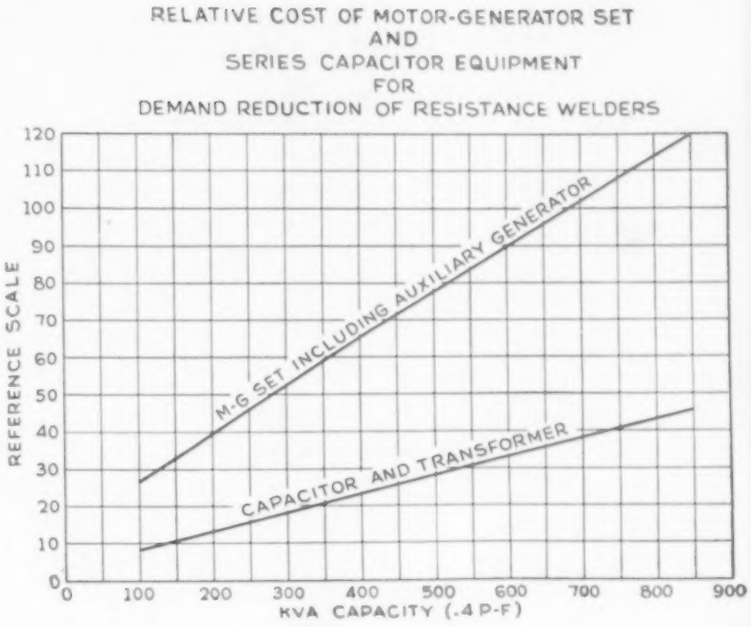


Fig. 3

Advantages Offered by Series Capacitors

As indicated, the use of series capacitors on low power factor loads will reduce the line demand as much as 60 to 75% and it might be assumed that the voltage drop in the high voltage system, step-down transformers and low voltage bus will be reduced by a proportionate amount. Improving the power factor, however, so changes the phase relation between the transformer voltage and the line reactive drop that the reduction in the case of a very low power factor load might be 10 to 1 instead of the 3 to 1 reduction in current. This is of particular importance where low voltage bus or feeder has been loaded to a point where the voltage at the end of the feeder is insufficient to insure satisfactory welding.

When used with magnetic contactor control the use of series capacitors in addition to their primary function reduces the high current transients common to non-synchronous control and thereby serves to improve the quality of the welded product. Also when used with magnetic contactors series capacitors sometimes permit the use of a smaller contacting device and in all cases reduce to service on contact tips.

Since series capacitors neutralize the reactive component of the machine impedance a deep throat machine will demand little more current than a shallow throat machine for making the same weld.

Space requirements are frequently an important consideration and it is interesting to note that the capacitor for a 300-kva. demand, 35% power factor machine is only 75 in. high, 30 in. wide and 35 in. deep. Requiring no attention whatever capacitors may be hung from the ceiling or mounted on a deck above the machine as shown in Fig. 2.

With all of these advantages it should be understood that the use of series capacitors in no way interferes with any welding technique developed on a non-corrected machine because the welding current remains unchanged, the only correction taking place on the line side of the welding transformer.

In using series capacitors with electronically controlled welders, a modified form of control becomes necessary due to the change in the power factor and voltage characteristics of the load. In the case of new equipment the additional cost represented by these modifications is insignificant.

Conclusion

Because of the greater use of high demand welders and the tendency for kva. ratings of machines to increase as wider application is made of resistance welding the problem of demand reduction becomes more and more acute. It is probable that in the not far distant future large machines will be ordered from the manufacturer complete with demand correction equipment.

Where difficulties have arisen on existing installations due either to cross interference between welders or due to interference with other electrical equipment on the line demand, correction of the offending load should always be investigated before reinforcement of the power supply system or the distribution system is undertaken. Also where rate structures are such as to place a power cost penalty on the user of high demand low power factor loads, the cost of demand correction equipment will frequently pay for itself in a very short time.

In considering correction equipment the use of series capacitors will in general reduce the demand current to an amount equal to or less than that obtained by the use of a motor generator set even though the rotating equipment affects a three-phase distribution of the load.

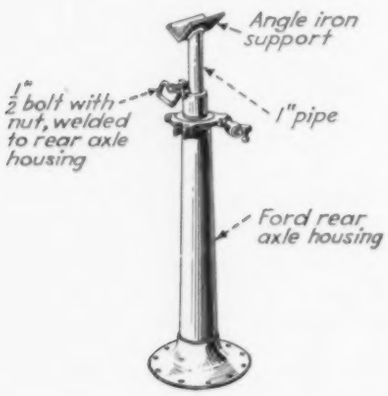
The cost of series capacitors will represent approximately 35% of the cost of a motor generator set for the same kva. load.

Practical Kinks on How to Make It

By George Sykes*

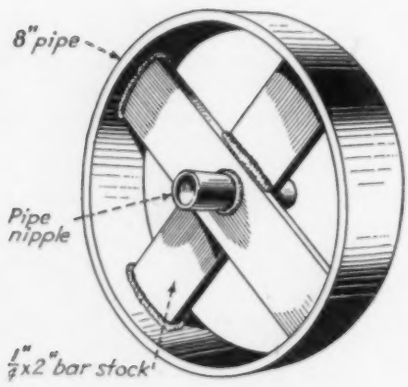
THIS shop and plant equipment is readily fabricated with the welding and cutting blowpipe.

Adjustable Pipe Stand



This adjustable pipe stand is a particularly handy piece of equipment for supporting the free end of a long length of pipe when the other end is held in a vise. The short length of angle iron is welded to a 1-in. pipe. Vertical adjustment is obtained by means of the set-screw which is made of a $^1/_2$-in. bolt and nut.

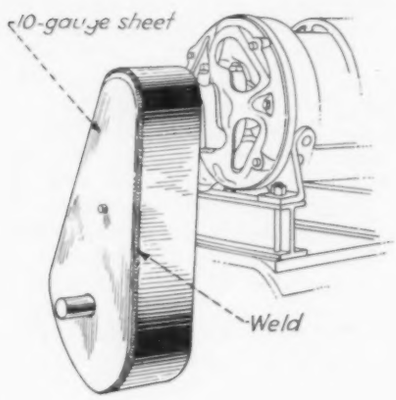
Strong Hand-Truck Wheels



Here is a simple method for making hand-truck wheels to replace broken cast-iron wheels. The rim is $1^1/_2$ in. wide and is hand-cut from a section of 8-in. diam. pipe. The spokes consist of $^1/_4$ x 2-in. bar stock bronze-welded to the inside of the rim. The pipe nipple, which serves as a bearing, is bronze-welded to the spokes.

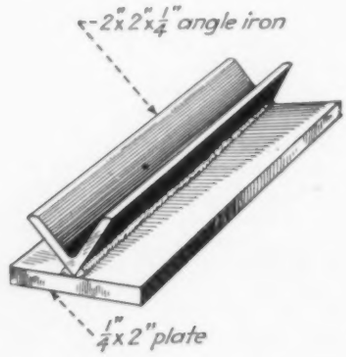
* The Linde Air Products Co., New York, N. Y.

Noiseless Safety Guards



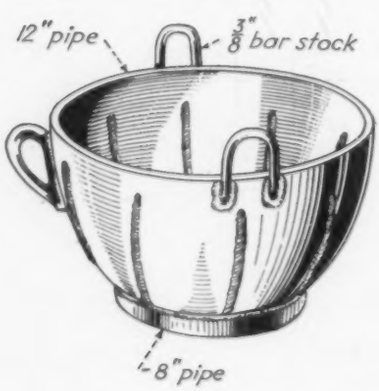
Safety guards over gears, belts and other moving machine parts can be fabricated by cutting suitable shapes from 10-gage sheet, heating and bending them to shape, and welding them with steel or bronze rod. Such guards can be made in half the time required for screwed guards, and are strong, neat and free from noise and vibration.

Handy Jig for Holding Rounds



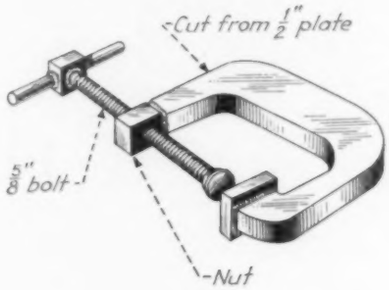
This sketch shows how to make a convenient holder for use when welding drills, rounds, or even square bar stock. It consists of a piece of 2 x 2 x $^1/_4$-in. angle iron welded to a piece of $^1/_2$ x 4-in. steel plate. The two pieces to be welded are aligned by placing them in the angle iron and butting the beveled ends together.

Babbitt Pots from Pipe



Fabricated steel pots give twice the service of the usual cast-iron pots which are apt to crack from repeated heating and cooling of the babbitt metal. The steel pots are made by cutting and welding large-diameter pipe to form an orange-peel head. The base is made by cutting a section from a smaller-diameter pipe or by bending a piece of 1-in. bar stock to form a circle. The pot is hung by means of two loops made of $^3/_8$-in. round bar stock, while a third loop aids in pouring operations.

Simple C-Clamps



C-clamps can be readily fabricated by hand-cutting a C-shaped section from $^1/_2$-in. plate. The clamping device, shown in the sketch, consists of a standard $^5/_8$-in. bolt with the nut welded to the plate. A short length of round bar stock welded to the bolt head serves as a handle.

Current Welding Literature

Acetylene Generators. Tips on Acetylene Generator Maintenance. Oxy-Acetylene Tips, vol. 20, no. 8 (Aug. 1941), pp. 187–188.

Airplane Manufacture. Junkers Experiments in Spot Welding. W. Borstel. Aircraft Eng., vol. 13, no. 144 (Feb. 1941), pp. 55–56.

Airplane Manufacture. Welding Stainless Aircraft Steels. Aircraft Eng., vol. 13, no. 148 (June 1941), p. 176.

Automatic Arc Welding. Mech. World, vol. 110, no. 2852, Aug. 29, 1941, pp. 135–136.

Bridge Piers, Construction. Skyscraper Piers. Construction Methods, vol. 23, no. 7 (July 1941), pp. 62–63, 97 and 100.

Bridges, Suspension. Ailing Suspension Bridge Restored, D. B. Steinman and J. London. Eng. News-Rec., vol. 127, no. 11 (Sept. 11, 1941), pp. 359–362.

Cars, Tank. First All-Welded Tank Cars of Nickel-Clad Steel. Western Machy. & Steel World, vol. 32, no. 8 (Aug. 1941), pp. 414–415.

Electric Welding, Arc. High-Speed Arc-Welding, S. G. P. De Lange and E. S. Waddington. Mech. World, vol. 110, no. 2851, (Aug. 22, 1941), pp. 122–123.

Electric Welding, Arc. How to Get Most from Arc Welding—III and IV, E. W. P. Smith. Steel, vol. 109, nos. 9 and 11 (Sept. 1, 1941), pp. 74–75 and (Sept. 15), pp. 88 and 174; vol. 109, no. 13 (Sept. 29, 1941), pp. 62, 64 and 67.

Electric Welding Machines, Control. Ampere-Squared-Second Recorder, T. A. Rich. Elec. Eng., vol. 60, no. 8 (Aug. 1941) (Trans.), pp. 839–842.

Electric Welding Machines. Direct-Current Welding with Transformer, C. E. Smith. Sheet Metal Industries, vol. 15, no. 173 (Sept. 1941), pp. 1171–1172 and 1174.

Framed Structures. Design of Welded Rigid Frames, V. A. Murphy. New Zealand Instn. Engrs.—Bul. & Proc., vol. 27, no. 1 (Apr. 15, 1941), pp. 86–134, supp. plates.

Heat Treatment. Oxyacetylene Flame Hardening, J. G. Magrath. Am. Mach., vol. 85, nos. 13, 14, 15, 16 and 17 (June 25, 1941), pp. 581–583 (July 9), pp. 645–647 (July 23), pp. 698–699 (Aug. 6), pp. 748–749 and (Aug. 20), pp. 804–806.

Iron and Steel Plants. Welded Open Hearth Auxiliaries, C. C. Keyser. Iron & Steel Engr., vol. 18, no. 7 (July 1941), pp. 52–57 (discussion) 57–58.

Light Metals. Spot Welding of Light Alloys, G. H. Field and H. Sutton. Aircraft Eng., vol. 13, no. 143 (Jan. 1941), pp. 17–26.

Magnesium. Welding of, H. O. Hoglund. Am. Mach., vol. 85, no. 14 (July 9, 1941), pp. 637–640.

Malleable Iron Castings. Flame Hardening Malleable Iron, S. Smith. Heat Treating & Forging, vol. 27, no. 8 (Aug. 1941), pp. 381–382 and 400–404.

Malleable Iron, Oxy-Gas Hardening. Flame-Hardening Malleable Iron, S. Smith. Am. Foundrymen's Assn.—Trans., vol. 49, no. 1 (Sept. 1941), pp. 209–222 (discussion), 222–224.

Manganese Steel. Welding Technique for Manganese Steel, D. B. Rice. Iron Age, vol. 148, no. 11 (Sept. 11, 1941), pp. 54–58.

Metals. ABC's of Metal Properties. Oxy-Acetylene Tips, vol. 20, nos. 8 and 9 (Aug. 1941), pp. 183–187 and (Sept.), pp. 197–200.

Metals, Hard Facing. Building Up and Hard Facing in Steel Plant, L. Ames. Iron & Steel Engr., vol 18, no. 8 (Aug. 1941), pp. 40–47 (discussion), 47–49.

Metals Testing. Principles of Magnaflux Inspection, F. B. Doane. Magnaflux Corp., Chicago, 1940. 133 pp., illus., diagrs., charts, tables, $2.50.

Military Applications. Welding in Wartime, H. J. Gough. Mech. Eng., vol. 63, no. 10 (Oct. 1941), pp. 732–733.

Motor Truck Manufacture. In Motor Truck Shop. Oxy-Acetylene Tips, vol. 20, no. 8 (Aug. 1941), pp. 178–179.

Nickel Alloys. Joining Nickel Alloys. Aircraft Production, vol. 3, no. 33 (July 1941), pp. 244–247.

Oscilloscopes. New Oscilloscope: Aid to Good Resistance Welding, L. G. Levoy, Jr., and C. H. Schermerhorn. Gen. Elec. Rev., vol. 44, no. 7 (July 1941), pp. 391–395.

Oxy-Acetylene Welding. Some Practical Hints on Oxy-Acetylene Welding, A. J. T. Eyles. Sheet Metal Industries, vol. 15, no. 171 (July 1941), pp. 925–926 and 934.

Petroleum Industry. Welding Recognized as Essential in Defense, H. P. Rigsby. Oil & Gas J., vol. 40, no. 17 (Sept. 4, 1941), p. 48.

Petroleum Pipe Lines. First Emergency Oil Line 236 Miles Long Built on 120-Day Schedule. Construction Methods, vol. 23, no. 9 (Sept. 1941), pp. 42–44.

Petroleum Pipe Lines. Piping Oil from Maine to Montreal. Eng. News-Rec., vol. 127, no. 9 (Aug. 28, 1941), pp. 285–287.

Pipe, Cast Iron, Standards. Manual for Computation of Strength and Thickness of Cast Iron Pipe. New England Water Works Assn.—J., vol. 55, no. 1, Mar. 1941 (Supp. Sec.), 59 pp.

Pipe, Cast Iron, Standards. Specifications for Cast Iron Pit Cast Pipe for Water or Other Liquids. New England Water Works Assn.—J., vol. 55, no. 1, Mar. 1941 (Supp. Sec.), 21 pp.

Pipe Lines. Developments in Pipe-Line Construction Methods, B. M. Laulhere, Jr. Oil & Gas J., vol. 40, no. 18 (Sept. 11, 1941), pp. 39–40 and 44.

Power Supply, Electric Welding. New Circuits, Better Welds, T. O. Morgan. Factory Mgmt. & Maintenance, vol. 99, no. 9 (Sept. 1941), pp. 92–93.

Railroad Maintenance of Way. Flame-Straightening Angle Bars in Track. Ry. Eng. & Maintenance, vol. 37, no. 9 (Sept. 1941), pp. 601–602.

Rails, Testing. Seven Years of Continuous Welded Rail on Delaware & Hudson, P. O. Ferris. Ry. Age, vol. 111, no. 8 (Aug. 23, 1941), pp. 312–316.

Shipbuilding. Bronze-Welding Speeds Repair of Damaged Axis Cargo Vessels. Oxy-Acetylene Tips, vol. 20, no. 8 (Aug. 1941), pp. 173–177.

Shipbuilding. Welding in Motor Ship Construction, K. Soderlund. Brit. Motor Ship, vol. 22, no. 256 (May 1941), pp. 48–54.

Steel Castings. Some Developments in Repair by Welding of Finished-Machined Castings, C. G. Lutts and P. Ffield. Am. Soc. Naval Engrs.—J., vol. 53, no. 3 (Aug. 1941), pp. 491–501, 5 supp. plates.

Symbols. How to Prepare Drawings for Structural Welding, L. Grover. Eng. News-Rec., vol. 127, no. 9 (Aug. 28, 1941), pp. 310–312.

Tubes, Welded Steel. Gas-Welding Machine Produces Stainless Steel Tubing. Steel, vol. 109, no. 10 (Sept. 8, 1941), pp. 84 and 87.

Welding. Progress of British Welding Research. Sheet Metal Industries, vol. 15, no. 172 (Aug. 1941), pp. 1052 and 1054.

Welding as Industrial Tool, H. Thomasson. Can. Machy., vol. 52, nos. 7 and 8, (July 1941), pp. 71–72 and 74, and (Aug.), pp. 89–90 and 92.

Welds, Cracking. Cracks in Fillet Welds, E. Helin. Iron & Coal Trades Rev., vol. 143, no. 3828 (July 11, 1941), p. 29.

Welds, Testing. Some Errors Which Are Commonly Made in Testing Welds, W. Herscovitch. Sheet Metal Industries, vol. 15, no. 173 (Sept. 1941), pp. 1175–1176.

Welding Society

ACTIVITIES — Related Events

22nd ANNUAL MEETING

All those who attended the 22nd Annual Meeting of the AMERICAN WELDING SOCIETY and the Metal Congress and Exposition are unanimous in their opinion that it was the most successful in the history of the SOCIETY.

The registered attendance was 1723, a trifle short of the mark set by Cleveland last year. The attendance at the Metal Show was in the neighborhood of 40,000. The attendance at the Annual Banquet of the SOCIETY was over 500. Altogether some 63 papers were presented at some 18 technical sessions. Several dozen committee meetings of one kind or another were held during the sessions. There were a number of round-table conferences and discussions on Industrial Research, Fundamental Research, Education, Section Officers, Representatives of the Resistance Welding Industry, and the like. It would be impossible to single out any particular event as being the most important. Special mention, however, should be made of the President's Reception, the program for the ladies, the award of medals and prizes, and, particularly, the Annual Banquet.

The Philadelphia Section and its numerous committees, whose names were published in the Annual Program, deserve particular credit for their cooperation with corresponding national committees in assuring the successful and smooth operation of all the events. The banquet will be long remembered for its entertainment and for the excellent menu.

There were many unusual features at the Metal Show. The companies outdid themselves in the display of their wares and the significance of their new developments in national defense work. Governmental organizations, quick to realize the importance of the occasion, cooperated fully both in the presentation of papers and in numerous displays at the Show.

All in all, the 22nd Annual Meeting was a grand success. Papers presented will be published as rapidly as possible in current issues of the JOURNAL. Written discussion is invited.

PRESIDENT'S REPORT TO THE MEMBERS OF THE AMERICAN WELDING SOCIETY

For the Administrative Year Ended September 30, 1941

By G. F. JENKS

The annual summary of the Society's operations will be found in the reports of the Secretary, and the Chairman of the Committee on Outline of Work, which will be published in the Year Book. This report will be confined to a discussion of some features of the Society's operations.

National Defense.—In times like these, when National Defense is paramount, technical societies become of increasing importance in educational, standardization and research fields. They are the medium through which the experiences of industries which have been engaged in peacetime manufacture become available to war industries. They are going organizations, made up of leaders in various fields, and represent producer, fabricator and consumer interests. Committees of technical societies are trained to consider all points of view in the solution of problems and to cooperate through mutual tolerance and recognition. It is greatly to the advantage of our National Government that the technical societies be utilized for National Defense.

Your Society has not only offered its services but has also organized activities which it is believed are of benefit to National Defense.

In times of rapid expansion of an industry, the training of skilled workmen and the utilization of existing engineering knowledge are difficult problems. The Society's work in preparing a Code of Minimum Requirements for Trade Schools should assist in raising the standards of some of the welding schools and in furnishing better trained welders. Our standardization activities are being accelerated and extended into new fields.

Of recent standards work undertaken the most urgently needed is in the field of aircraft welding. At the request of the O. P. M. this Society has, in cooperation with the National Aircraft Standards Committee, organized an Aircraft Welding Standards Committee. This Committee will work through the N. A. S. C. to determine whether proposed standards are acceptable to the aircraft industry before they are promulgated by the Society.

The urgent need for aircraft welding standards was first recognized by the Resistance Welding Research Committee which proposed some preliminary standards. In organizing a Standards Committee in this field, the Society recognized the necessity of prompt inauguration of the work without the delays usual in the formation of a new committee. When this policy was announced, the Taylor-Winfield Corporation offered to make the services of George S. Mikhalapov available for aircraft resistance welding standards work, provided that his travel and office expenses were paid. The Society accepted this offer and voted to advance $2000 from its treasury to inaugurate the work. Later, the Resistance Welder Manufacturers' Association voted $2500 for the same purpose and has turned over a portion of that amount to the Society. The work has been in progress for several months. As the work upon which Mr. Mikhalapov is engaged is that usually accomplished by engineers of industrial companies, it is hoped that the aircraft industry will later assume this financial burden. The use of similar methods in other fields of aircraft welding is under study.

The program of the Society's Pacific Coast Division Meeting at Los Angeles and of the current Annual Meeting emphasize National Defense subjects. Our Sections have also devoted much of their efforts to these subjects and to educational programs. The offer of prizes by the Summerill Tubing Company has stimulated the submission of papers on the welding of aircraft steels.

A needed contribution is the preparation of the Second Edition of the Welding Handbook. It is hoped that this will be completed early during the coming year.

Organization.—Two important changes have been made in the Society's organization. For improved administration two Advisory Committees have been organized and a third one authorized. A Section Advisory Committee is engaged in studying problems affecting sections and members. A Resistance Welding Advisory Committee was organized to make recommendations on matters pertaining to that industry. Both of these committees have been helpful. It may be found desirable to organize similar committees for other industries.

A far-reaching reorganization of the Society's technical work has been adopted as a result of recommendations by a Special Committee under the Chairmanship of Mr. O. B. J. Fraser. The changes will give greater authority and responsibility to our technical committees in respect to their membership, scope of work, and the initiation of standards activities. It will give them final jurisdiction over the technical contents of their standards. Under the changed rules and procedures the responsibility for the initiation and preparation of Standards rests with industry. The responsibility for organizing new fields of standards work rests with the Committee on Outline of Work under the Executive Committee. It is the Society's responsibility to secure compliance with its Rules of Procedure, to organize and supervise standards activities and to accept and publish standards.

DEVOTION TO DUTY IS A TELEPHONE TRADITION
High morale, devotion to duty, ingenuity in meeting new circumstances and the ability and will to work with each other and with the public are traditional characteristics of telephone employees.
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There remains to be studied the technical organization of the Society to determine whether committees as now organized are sufficiently representative of industry to function effectively. It is hoped that some of the present technical committees may be consolidated so that the review function may be more efficiently performed. Such consolidation would lessen the responsibility of the Outline of Work Committee in organizing standards work of a general nature and place it in a committee that is more representative of industry. These questions will be given study during the coming year.

Future Policy.—The Society is financially and technically in a healthy condition. It has not reached maturity in respect to membership or usefulness. Constant study must be made of its administrative and technical organizations to keep them responsive to the needs of industry and of members, wherever located. Some minor changes will probably be recommended during the coming year.

A great need of the times is greater output in the field of standards. Our technical committees will be encouraged and stimulated to make good engineering practice available in recommended practices, standards and codes.

Acknowledgments.—It is desired to acknowledge the loyal and efficient services of the Society's Headquarters Staff, the individual and collective services and advice of the Executive Committee and of the several administrative and special committees that have reported directly to the Board of Directors. Acknowledgments are also due to our various technical committees and especially to the Outline of Work Committee.

AWARD OF MEDALS AND PRIZES OPENS ANNUAL WELDING MEETING

Presentation of awards and medals for outstanding contributions to welding during the past year opened the 22nd Annual Meeting of the AMERICAN WELDING SOCIETY at the Bellevue-Stratford, Philadelphia, at 9:30 A.M., Monday, October 20th.

Left to right: Hanford Eckman, Piper Aircraft Corp., recipient of first prize in the Summerill Aircraft Contest; Col. G. F. Jenks, Ordnance Dept., President, American Welding Society; J. P. Dods, Summerill Tubing Co. The Summerill Company was donor of the prizes

The Miller Medal for conspicuous contributions to the art and science of welding during 23 years went to David Arnott, Vice-President and Chief Surveyor of the American Bureau of Shipping, also Second Vice-President of the AMERICAN WELDING SOCIETY.

Lincoln Gold Medal for the paper which contributed most to the past year's development of welding was awarded to R. H. Aborn, member of the staff of the Research Laboratory of the United States Steel Corporation, Kearny, N. J.

Resistance Welders Manufacturers' Association prizes for papers contributing to progress in resistance welding were presented as follows:

First prize of $300 jointly to A. M. Unger, K. A. Matis and E. P. Cruca, all associated with Pullman-Standard Car Manufacturing Company of Chicago.

Second prize of $200 jointly to G. S. Mikhalapov and G. N. Weygandt. Mr. Mikhalapov is Director of Research for Taylor-Winfield Corporation, Warren, Ohio.

Third prize of $100 to J. R. Fetcher of E. G. Budd Manufacturing Company, Philadelphia.

Fourth prize of $25 to A. M. Unger, Development Engineer, Pullman-Standard Car Manufacturing Company of Chicago.

Fifth prize of $25 jointly to W. B. Kouwenhoven and J. Tampico. Mr. Kouwenhoven is Professor of Electrical Engineering, Johns Hopkins University, and Mr. Tampico is Dr. Engineering, Johns Hopkins University, and Second Lieutenant of the Ordnance Department.

Sixth prize of $25 jointly to M. L. Wood, J. Babin and O. B. Atkin.

Seventh prize of $25 jointly to H. B. Axtell and R. L. Ringer.

The awards in the Summerill Aircraft Contest were presented as follows:

First prize of $300 to Hanford Eckman, Piper Aircraft Corporation, Lock Haven, Penna.

Second prize of $200 to F. H. Stevenson, Vega Airplane Company, Burbank, Calif.

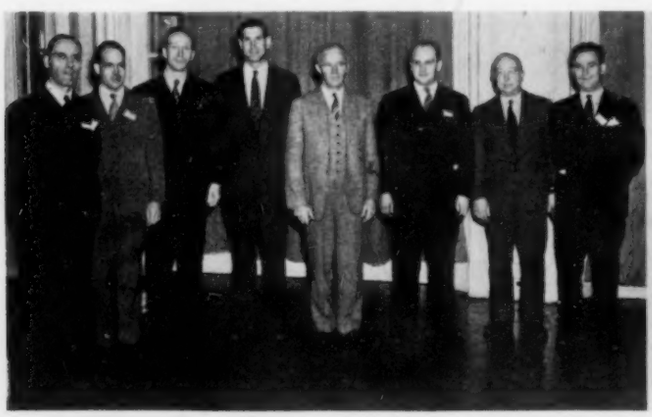
Third prize of $100 divided equally between F. R. Kostoch, North American Aviation, Inc., Inglewood, Calif., and C. J. Hertel of Douglas Aircraft Company, Inc., Santa Monica, Calif.

MILLER MEDALIST DAVID ARNOTT

Presentation by D. S. Jacobus

Mr. David Arnott was born in Glasgow, Scotland, in 1878. He received his education at the Royal Technical College, in Glasgow, and served his apprenticeship in shipbuilding at the Fairfield Shipbuilding and Engineering Co., Ltd., Glasgow. In 1901 he was appointed a surveyor of the British Corporation for the Survey and Registry of Shipping, a position which he held in the head office in Glasgow until 1917. In that year he was appointed the Society's Principal Surveyor to Canada. In 1918 he came to New York as Deputy Chief Surveyor of the American Bureau of Shipping, a position he held until 1925, when he became Chief Surveyor. To his duties as Chief Surveyor were added in 1938 those of Vice-President. He still holds both these offices. Mr. Arnott became a naturalized citizen of the U. S. A. in 1924.

His affiliations with technical affairs are numerous and include: Council Member, Society of Naval Architects and



Left to right: M. S. Clark, President, Resistance Welder Mfrs. Assn.; G. N. Weygandt, Rensselaer Polytechnic Institute, Troy, N. Y.; G. S. Mikhalapov, Dir. of Research, Taylor-Winfield Corp., Warren, Ohio; John R. Fetcher, E. G. Budd Co., Philadelphia, Penna.; W. B. Kouwenhoven, Prof. of Electrical Engineering, Johns Hopkins University; A. M. Unger, Development Engineer, Pullman Standard Car Mfg. Co.; M. L. Wood, Chase Brass & Copper Co.; J. Babin, Chase Brass & Copper Co.

Left to right: C. H. Jennings, Westinghouse Electric & Mfg. Co., Chairman, Board of Awards; Col. G. F. Jenks, Ordnance Dept., Washington, D. C., President of the American Welding Society; Dr. R. H. Aborn, Recipient of Lincoln Gold Medal; David Arnott, American Bureau of Shipping, Recipient of Samuel Wylie Miller Memorial Medal; Dr. D. S. Jacobus, Member of the Board of Awards

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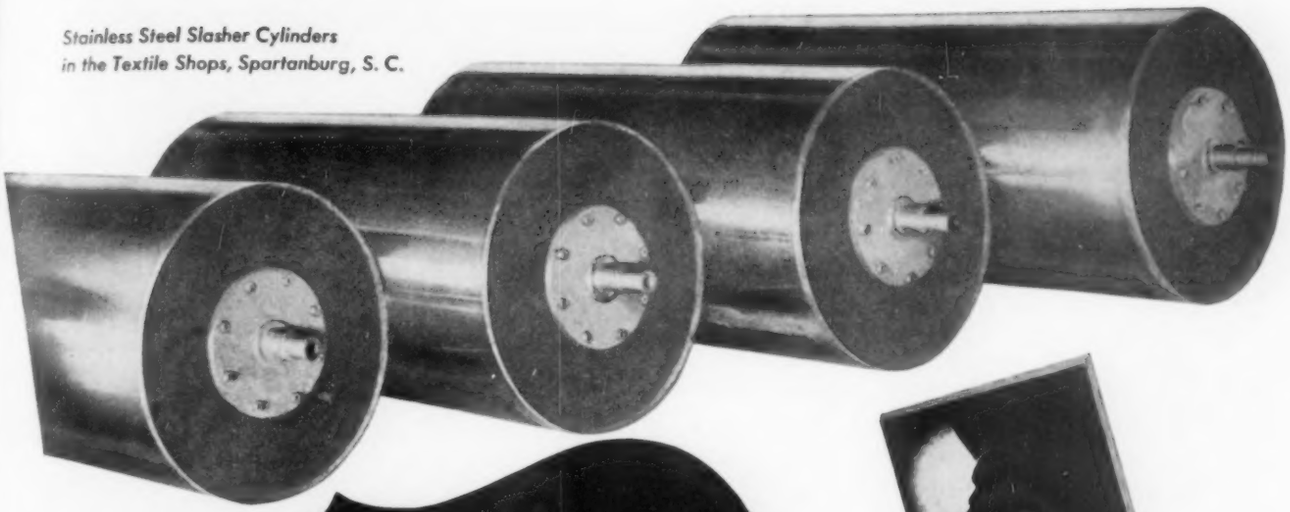

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David Arnott

Marine Engineers; Member, Institution of Naval Architects; Member, British Institute of Welding; Second Vice-President, AMERICAN WELDING SOCIETY; Chairman of Committee on Welding in Marine Construction, A. W. S.; Technical Adviser to U. S. Delegation, International Safety of Life at Sea Convention 1929; U. S. Delegate to International Load Line Convention 1930.

He is author of "Some Examples of Welded Ship Construction" presented before the Society of Naval Architects and Marine Engineers in 1934, and "Welding in Shipbuilding" delivered last year to the AMERICAN WELDING SOCIETY. One of the chapters in the Welding Handbook was contributed by him. In the *Principles of Naval Architecture* published by the Society of Naval Architects and Marine Engineers he wrote the chapter on "The Strength of Ships." He has written extensively on load lines and the safety of life at sea.

The Bureau of Shipping, with which Mr. Arnott has been associated for the last 23 years, has played a prominent part in the application of welding to ship construction. This application was one of gradual evolution, whereby welding at first was used in assembling parts of the ship which were not of importance structurally. In 1927 the American Bureau of Shipping made possible full classification for all-welded vessels, the first classification society in the world to do so.

The rapid progress in the art of welding as applied to merchant shipbuilding in this country has in large measure been due to the policy of the Bureau, which has tried to avoid arbitrary onerous restrictions, while at the same time insisting that strength and workmanship standards be adequately met. The Bureau has endeavored to keep its regulations in step with the rapid advancement made in the art of welding, and has always been willing to consider modifications in the design of ships to get the benefit of the economic advantages of welding. The standards of welding which were tabulated by the Bureau were the earliest comprehensive tables for the use of welding in ship construction. In regard to the policy of simplification which the Bureau has sponsored, it is encouraging to note that a reciprocity agreement among the American Bureau of Shipping, the Bureau of Marine Inspection and the Navy has come to fruition, whereby welding operations certified by one agency will be accepted as qualified by the others.

Mr. Arnott's close association with the technical activities of the AMERICAN WELDING SOCIETY has been of great benefit to the Bureau in setting up standards for the classification of all-welded vessels.

I am happy to announce that the AMERICAN WELDING SOCIETY has awarded the Samuel Wylie Miller Memorial Medal to Mr. David Arnott for the leading part he has taken in the advancement and use of welding in ship construction. A ship is a live structure from the standpoint of loading as it is continuously weaving and straining under service conditions. The forces to which it is subjected are not readily determinable. It requires a broad sense of proportions and sound judgment to develop a safe and practicable design when as radical a change is made as employing an all-welded construction. Mr. Arnott has certainly done wonderful work in establishing safe practices and at the same time promoting progress in a field where there were many special problems

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to solve and difficulties to be overcome. Those who are blessed with a love for the sea are best fitted to master its merciless forces. We all congratulate him on his wonderful achievements. It gives me great pleasure to present this medal to Mr. Arnott and to assure him that his many friends and admirers unanimously agree that he richly deserves the honor.

REPLY BY DAVID ARNOTT

Dr. Jacobus, Mr. President, Ladies and Gentlemen: I feel highly honored at being selected as the 1940 recipient of the Samuel Wylie Miller Memorial Medal. I appreciate the remarks made by Dr. Jacobus, which are altogether too flattering. My personal contribution to the art of welding can be stated very briefly, namely, that after a healthy attack of skepticism which was not unduly prolonged I realized the advantages to be achieved by the application of arc welding to ship construction and proceeded to do what I could both unofficially and in my official capacity as Chief Surveyor of the American Bureau of Shipping to encourage its development in our shipyards. Of all branches of structural engineering, shipbuilding had most to gain from the new process, if only in view of the very appreciable economies resulting from a saving in hull weight of from 15 to 20%.

The growth of ship welding in the United States especially during the last decade has been remarkable. In 1929, out of the vessels building to class with the American Bureau only one small oil barge, 100 feet long, fittingly named the *Pioneer* was of welded construction. On October 1st of this year there were 1009 ships building or contracted for to American Bureau of Shipping classification. Of these ships 298 are under 300 feet long and are all welded except one small survey vessel. Of the 711 larger ocean-going ships, no fewer than 207 are completely welded and in the remaining 504 ships welding is used very extensively. In short, 50% of all the merchant ships building at present in the U. S. are completely welded.

Arc welding was at first confined to the smaller types of vessels, mostly oil tank barges, and the most noteworthy step in advance was made by the Sun Shipbuilding Company when they built the large ocean-going tanker *J. W. Van Dyke* for the Atlantic Refining Company. The policy of the Maritime Commission in permitting builders to use welding at their discretion for all parts of the hull structure has also encouraged the adoption of welding for the construction of large ocean-going ships. The defense program has tremendously accelerated ship welding, our new shipyards all having been designed and laid out primarily with a view to mass production of welded ships. It is anticipated that some of these yards when in full production will deliver a cargo ship per week. I venture to say that the defense program would not have been so far ahead today if it had not been for the general adoption of welding.

There are still many problems relating to the welding of structures which await a complete solution, and in my opinion these can best be solved through the facilities afforded by the research committees of the AMERICAN WELDING SOCIETY. There has been some criticism of the Society for not issuing codes of practice for every kind of conceivable structure under the sun, and, on the other hand, for trying to do too much in this respect. Having had something to do with drawing up and administering rules for ship construction throughout the best part of a long business career, I feel free to emphasize the fact that any regulations which fail to keep pace with modern developments will inevitably serve only as a restraint of trade, that while a reasonable amount of standardization is beneficial and indeed essential in our modern industries, unnecessary and premature standardization can be distinctly harmful and that nothing can be more demoralizing to business generally than interference without facilitation.

I have been associated with the AMERICAN WELDING SOCIETY for a good many years, and the possibility of its being administered along other than sound lines in the future as in the past is to me hardly conceivable. I have nothing but admiration for the manner in which it has grown in stature and importance throughout the years in an endeavor to meet the ever-increasing demands of our basic

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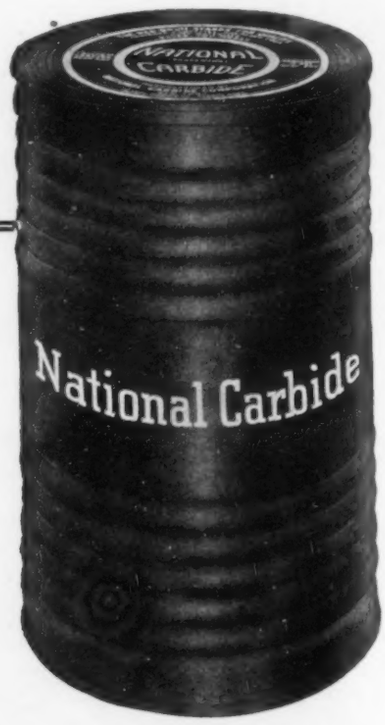

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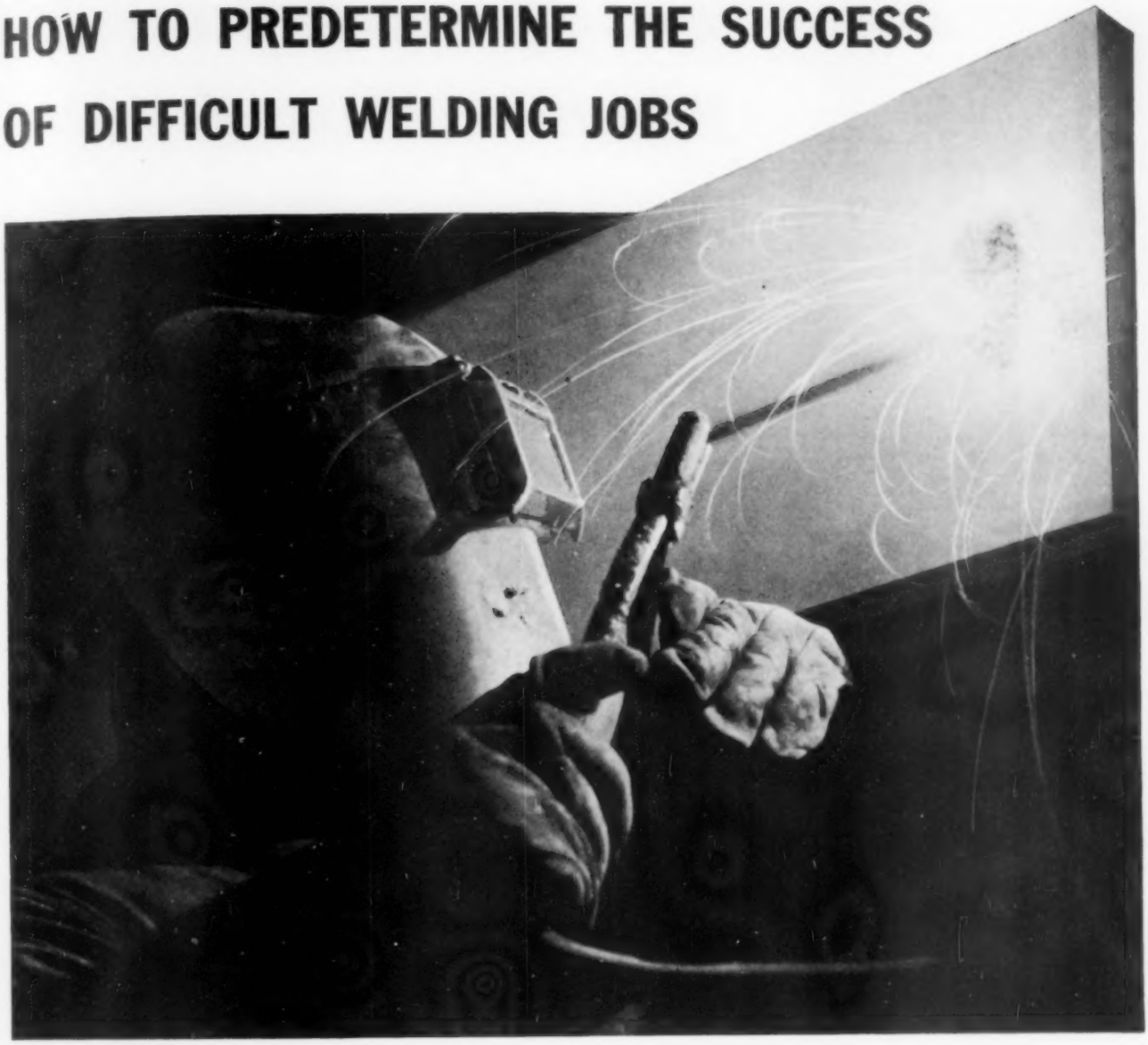

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industries. Too much cannot be said in praise of the work of the pioneers of the Society, of whom Samuel Wylie Miller was an outstanding example, and I am very proud indeed to be a recipient of the Memorial Medal which bears his name.

LINCOLN MEDAL AWARD

Award of the Lincoln Gold Medal, donated to the AMERICAN WELDING SOCIETY by James F. Lincoln, president of The Lincoln Electric Company, Cleveland, Ohio, was made to Robert H. Aborn, member of the staff of the Research Laboratory of the United States Steel Corporation, Kearney, New Jersey.

The Lincoln Award, which is presented each year for the paper which contributes most to the year's development of welding, was made for "Metallurgical Changes at Welded Joints and the Weldability of Steels," published in the October 1940 issue of THE WELDING JOURNAL and presented at the annual meeting in Cleveland October 21 to 25, 1940.

Mr. Aborn was born January 9, 1897, at Battle Creek, Mich. His education consists of an A.B. degree from Grinnell College in 1918, B.S. degree from Massachusetts Institute of Technology in 1920 and Sc.D. (in Metallurgy) from Massachusetts Institute of Technology in 1925. He was in the Chemical Warfare Service of the U. S. Army in 1918.

During 1920 and 1921, Mr. Aborn was in the blast furnace department of the

Robert H. Aborn

Bethlehem Steel Company and from 1923 to 1925 worked in the laboratory of the Watertown Arsenal. From 1925 to 1928 he was employed in the X-ray Division of the Research Laboratory of Applied Chemistry at Massachusetts Intsitute of Technology. From 1928 to 1930 he was instructor in metallurgy at the Engineering School of Harvard University. He was appointed to his present position on the staff of the Research Laboratory of the U. S. Steel Corporation in 1930.

BOARD OF DIRECTORS MEETING

The Board of Directors of the Society held a joint meeting with the Executive Committee in New York on September 18th. There were present: C. A. Adams, D. Arnott, A. G. Bissell, H. C. Boardman, R. W. Clark, E. V. David, O. B. J. Fraser, J. H. Deppeler, E. R. Fish, H. O. Hill, D. S. Jacobus, J. F. Lincoln, H. M. Priest, E. T. Scott, W. Spraragen and M. M. Kelly.

Report of Special Committee on Technical Organization

The substance of this report was described in an action of the preceding meeting of the Executive Committee. Further editorial changes were made in the report and necessary changes in the By-laws approved. These rules will be published shortly in the annual Year Book of the Society.

A. W. S. Retirement System

The Retirement Income Plan recommended by a special committee on Pension Plan was approved and the New England Life Insurance Company was selected as the underwriters of the Retirement Plan. Briefly, this plan calls for equal payment

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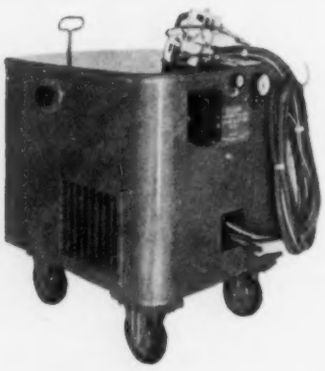

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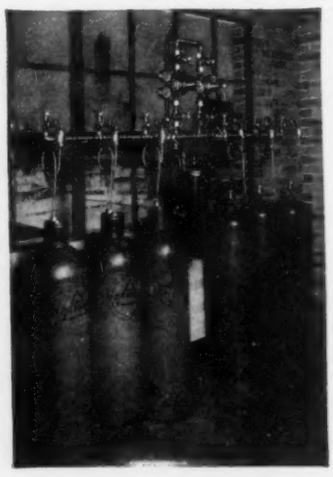

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Acme Electric Welder Company, Los Angeles, Calif.
American Electric Fusion Corporation, Chicago, Ill.
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Company, Detroit, Mich.
Federal Machine and Welder Company, Warren, Ohio
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City, Mich.
Progressive Welder Company, Detroit, Mich.
Swift Electric Welder Company, Detroit, Mich.
Taylor-Hall Welding Corporation, Worcester, Mass.
Taylor-Winfield Corporation, Warren, Ohio
Thomson-Gibb Electric Welding Co., Lynn, Mass.

ASSOCIATE MEMBER COMPANIES

P. R. Mallory and Co., Indianapolis, Ind.
S-M-S Corporation, Detroit, Mich.
Electroloy, Inc., New York, N. Y.
Welding Sales and Engineering Co., Detroit, Mich.

by the employees and by the Society; each contributing approximately 3% of the employee's salary.

Weldability Tests for Steel

The following Committee was appointed upon recommendation of the Committee on Outline of Work, as a Committee pro tem on Weldability Tests for Steel: N. L. Mochel, Chairman, Westinghouse Electric & Mfg. Co.; David Arnott, American Bureau of Shipping; Bureau of Ships, Navy Department; Paul Ffield, Bethlehem Steel Company; F. H. Frankland, American Institute of Steel Construction; H. J. French, International Nickel Company; LaMotte Grover, Air Reduction Sales Company; W. C. Hamilton, American Steel Foundries, East Chicago, Ind.; H. O. Hill, Bethlehem Steel Company; S. L. Hoyt, Battelle Memorial Institute; G. F. Jenks, Ordnance Dept., U. S. Army; C. H. Jennings, Westinghouse Electric & Mfg. Co.; J. B. Johnson, Wright Field; J. J. Kanter, Crane Company; E. F. Kenny, Bethlehem Steel Company; A. B. Kinzel, Union Carbide & Carbon Research Labs.; J. J. Leech, Carnegie-Illinois Steel Corporation; G. F. Mikhalapov, Taylor-Winfield Corporation; H. W. Pierce, New York Shipbldg. Corp.; J. F. Randall, Combustion Engineering Company.

Standard Procedures of Welding and Standards for Welded Joints

Upon recommendation of the Committee on Outline of Work, the following Committee pro tem was approved: C. H. Jennings, Chairman, Westinghouse Electric & Mfg. Co.; L. C. Bibber, Carnegie-Illinois Steel Corporation; H. C. Boardman, Chicago Bridge & Iron Company; Everett Chapman, Lukenweld, Inc.; E. R. Fish, The Hartford Steam Boiler Insp. & Ins. Co.

Aircraft Resistance Welding Standards Committee

As announced in the October JOURNAL an Aircraft Resistance Welding Standards Committee was approved with the understanding that when the Aircraft Welding Standards Committee is organized, the Aircraft Resistance Welding Standards Committee will become a subcommittee thereof. An Eastern and Western division of this Committee were appointed.

Welding Handbook

It was reported that despite all effort on the part of the Committee to expedite the publication of the *Welding Handbook*, delay in preparation of material on some of the chapters will probably postpone publication until January or February of 1942. Because of the great demand for the book here and abroad, the President expressed the hope that effort would be put into getting the book out before the end of this year.

ARC WELDING SCHOLARSHIPS

Recipients of The Arc Welding Scholarships in Welding Engineering established at The Ohio State University in 1939 are announced by Charles E. MacQuigg, dean of the University's College of Engineering, Columbus, Ohio.

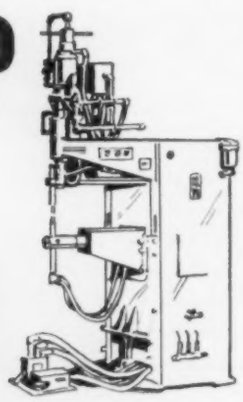
Recipients of the 1941–42 scholarships are William S. Wagner, a junior of Navarre, Ohio, and Robert Frederick Bluhm, a senior of Scottsdale, Pa. Both men have been employed during the summer, Mr. Wagner by the Griscom-Russell Company, Massillon, Ohio, in plant layout work and Mr. Bluhm at the Scottsdale Machine, Foundry and Construction Company, Scottsdale, Pennsylvania, in welding work.

In college activities, Mr. Wagner, is an active member of the Student Branch, AMERICAN WELDING SOCIETY, is on the Tower Club Year Book Committee, and a member of the "Ohio State Engineer" business staff. Mr. Bluhm is an Engineering Council representative, an active member of the Student Branch, AMERICAN WELDING SOCIETY and president of the Theta Tau social Professional Engineering fraternity.

The Arc Welding Scholarships, made possible by an anonymous donor, amount to $250 each and may be awarded annually to one junior and one senior student in the curriculum in Welding Engineering. Award of the scholarships is on the basis of: (*a*) scholastic record; (*b*) personality; (*c*) character; (*d*) leadership and participation in academic activities; (*e*) enthusiasm for and promise in Welding Engineering.

Award is made on recommendation of

SPEED-UP SPOT WELDING



NEW Oakite cleaning process for aluminum helps you get MORE welds in less time!

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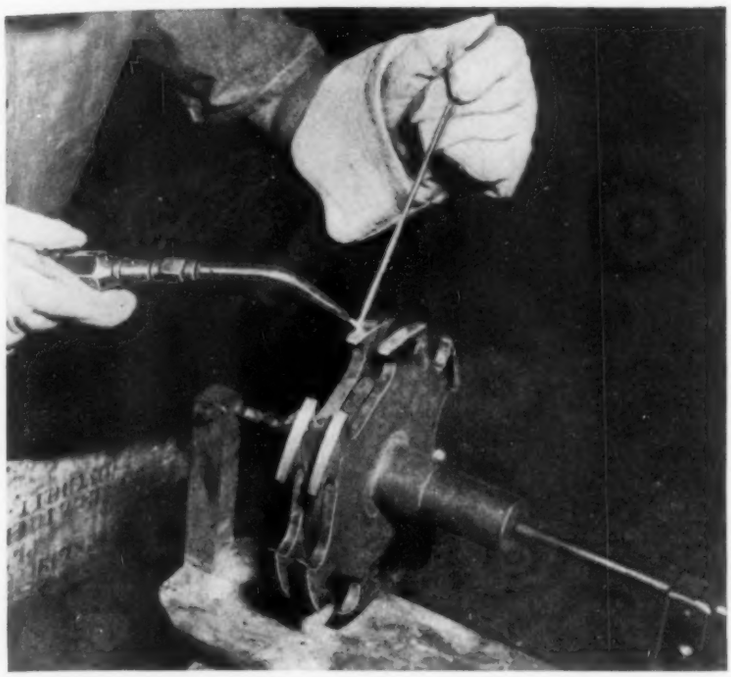


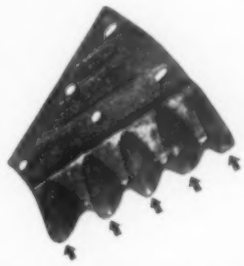
Supercharger Drive Shafts Last Longer

SUPERCHARGER drive shafts for aircraft-type engines which are used in P.T. boats are hard-faced by the engine manufacturer to assure long, trouble-free life. Haynes Stellite alloy is specified for these parts not only because it resists the metal-to-metal abrasion to which they are subjected, but also because this alloy does not seize or gall. Haynes Stellite No. 1 rod is applied to all twelve surfaces shown in the sketch at the left. The time required for the application was reduced from 2 hr. to only 1 hr. and 20 min. by use of the simple jig illustrated above.

Experienced Haynes Stellite Company representatives —and Linde service operators—can give you practical assistance in designing parts to be hard-faced, building jigs and fixtures, selecting the most suitable hard-facing rod, and developing a skillful hard-facing technique. Write or phone the district office nearest you.

Hard-Facing Hints

HAYSTELLITE Tube Rod applied to the teeth of this blade, used in an earth drilling machine, has increased its life 4 times as compared to the special steel used before



hard-facing was adopted. Haystellite rod is used for this application because of its outstanding resistance to abrasion.

PLOW SHARES — Hard-facing plow shares with Haynes Stellite rod or Haystellite tube rod is a source of profit to the welding shop and the farmer alike. The folders illustrated

above give step-by-step procedures for applying the rods most effectively and economically. One deals with Haynes Stellite rod—the other with tube rod. Write today for copies.

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committee consisting of: (*a*) the dean of the College of Engineering; (*b*) the chairman of the Department of Industrial Engineering; (*c*) the chairman of the Department of Electrical Engineering; (*d*) the professor of Welding Engineering; and (*e*) one other not necessarily from the faculty selected by the four specified.

The funds, originally deposited with the Board of Trustees of the University, provide for two scholarships per year for a period of 10 years.

BOUND VOLUME JOURNAL

The AMERICAN WELDING SOCIETY has made arrangements for members who wish to have their Journals for 1941 bound in attractive, imitation black leather covers, to do so by sending copies of the twelve issues to Russell-Rutter Company, Thirty-Third Street and Eighth Avenue, New York, N.Y., Att. Mr. Russell Lauben, Jr. A special reduced rate has been arranged at $2.50 per volume providing the issues of the JOURNAL are sent to the binder on or before Jan. 15, 1942. The bill for the binding and return postage will be sent direct from the Society's office.

OFFICE OF PRODUCTION MANAGEMENT—DIVISION OF PURCHASES

Increased production of steel from existing facilities during the national emergency by concentration on a minimum number of steel specifications, compositions, sizes and shapes is expected to result from a new project launched by the Office of Production Management.

At the request of OPM, three national organizations—the American Society for Testing Materials, Society of Automotive Engineers and the American Iron and Steel Institute—will carry out the project with the collaboration of the War and Navy Departments, under the general supervision of OPM. An Administrative Committee to direct the work has been formed of representatives of these five bodies with advisers from other interested organizations, and is headed by C. L. Warwick, Consultant, Office of Production Management, and Secretary-Treasurer of the A. S. T. M.

The goal as defined by the Administrative Committee at its first meeting on September 12th is to establish as promptly as possible a selected list of steel specifications, to be designated National Emergency Steel Specifications, which in effect involves the selection of the minimum number of steel specifications, compositions and sections necessary to meet the requirements of National Defense, both direct and indirect.

It is believed that the productive capacity of the steel industry, and of the manufacturing industries using steel for defense equipment, can be materially increased within present facilities by concentration of production upon a reduced number of steels, particularly with respect to alloy steels. Consideration will necessarily be given to non-defense requirements for steel in establishing the List of National Emergency Steel Specifications.

It is the intention of OPM, through its Iron and Steel Section, to use the list as an aid in administering steel priorities and allocations.

The Administrative Committee indicated that the purpose is not to write new specifications, but primarily to select from existing specifications the practical minimum, in order to get maximum production of planes, tanks, guns, ships and all other defense equipment.

A classification of steel products has been made, and committees of technical representatives of both users and producers of steel are being organized to handle the work. The committees on carbon and alloy steel plates, and on aeronautic steels, will be the first to get under way. These committees will take full advantage of the extensive standardization which has already been accomplished in this field. In all of this work, the committees will keep constantly in mind the degree of scarcity of critical metals and alloying elements and the need for conserving them for the most effective utilization in the defense program.

After review by the Administrative Committee, the recommendations of the technical committees will be referred to OPM.

The personnel of the Administrative Committee is as follows: C. L. Warwick, *Chairman*, Consultant, Office of Production Management.

MEMBERS

Representing the American Society for Testing Materials: N. L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric and Manufacturing Company. Alternate—Jerome Strauss, Vice-President, Vanadium Corporation of America.

Representing the Society of Automotive Engineers: F. P. Gilligan, Secretary-Treasurer, Henry Souther Engineering Company. Alternate—J. B. Johnson, Chief, Materials Section, Air Corps, U. S. A.

Representing the American Iron and Steel Institute: E. C. Smith, Chief Metallurgist, Republic Steel Corporation. Alternate—C. M. Parker, Secretary, Committee on Manufacturing Problems, American Iron and Steel Institute.

Representing the War Department: Lt. Col. W. R. Slaughter, U. S. A., Chief, Ordnance and Steel Divisions, Production Branch, Office of Under Secretary of War. Alternates—Major J. H. Frye, U. S. A., Ordnance, War Department; Lieutenant J. H. Fitch, U. S. A., Standards Division Planning Branch, Office of Under Secretary of War; J. B. Johnson.

Representing the Navy Department: Lt. Comdr. E. C. Forsyth, U. S. N., Bureau of Ships, Navy Department. Alternate—Lt. Comdr. J. E. Sullivan, U. S. N. R., Bureau of Aeronautics, Navy Dept. *Other alternates to be appointed.*

ADVISERS

H. S. Rawdon, Chief, Division of Metallurgy, National Bureau of Standards. Alternate—W. H. Swanger, Metallurgist, National Bureau of Standards.

N. F. Harriman, Vice-Chairman, Federal Specifications Executive Committee, Procurement Division, Treasury Department.

J. W. McNair, Engineer, American Standards Association.

H. LeRoy Whitney, Executive Consultant Iron and Steel Section, OPM. Alternate—G. B. Waterhouse, Consultant, Iron and Steel Section, OPM.

C. E. Stryker, Standards Coordination Branch, Aircraft Section, OPM.

C. W. Test, Steel Industrial Specialist, Civilian Allocation Division, OPM.

E. J. Hergenroether, Consultant, Conservation and Substitution Section, OPM.

K. D. Williams, Principal Materials Engineer (Metallurgical), Bureau of Ships Navy Department.

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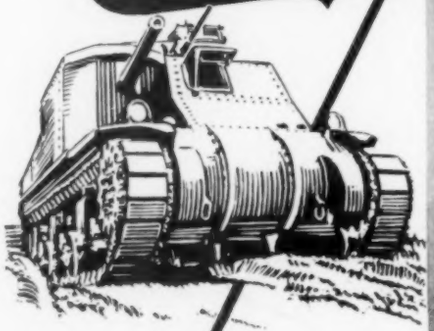

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GOVERNMENT arsenals take no chances with the quality of material used in armament production. For six years the 200,000 volt KELEKET X-ray apparatus shown above has been used for inspecting castings and welded parts.

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AMES W. PARKER ELECTED PRESIDENT A. S. M. E.

James W. Parker, Vice-President and chief engineer of the Detroit Edison Co., was elected by a letter ballot of the 15,000 members of The American Society of Mechanical Engineers to be President of the Society during 1942, according to the official announcement of the election results by C. E. Davies, Secretary of the Society.

Vice-Presidents elected at the same time to serve two-year terms on the Council of the A. S. M. E. were Clarke F. Freeman, senior Vice-President and engineer of the Manufacturers Mutual Fire Insurance Company and its associated companies, Providence, R. I.; C. B. Peck, managing editor of *Railway Mechanical Engineer*, New York, N. Y.; W. H. Winterrowd, Vice-President of The Baldwin Locomotive Works, Eddystone, Pa.; and W. R. Woolrich, dean of the College of Engineering, and director of the Bureau of Engineering Research of the University of Texas, Austin, Texas.

Managers of the Society elected to serve on Council for three-year terms include W. G. Christy, smoke-abatement engineer of Hudson County, New Jersey; H. L. Eggleston, manager of the gas and refining departments, Gilmore Oil Company, Los Angeles, California; and T. S. McEwan, who was last year selected to head the defense contract service of the Office of Production Management in Chicago as district manager.

The new officers will be installed during, the 62nd Annual Meeting of the Society in New York, N. Y., at the Hotel Astor, December 1-5, 1941.

AMPCO PUBLISHES NEW CATALOG

Ampco Metal, Inc., Milwaukee, Wisconsin, producers of bronze alloys have just issued Catalog 22 describing Ampco Metal, an alloy of the aluminum-bronze class. The new book is well illustrated with photomicrographs, parts and factory views. It contains descriptions of the alloys and a comprehensive table of physical properties and range of chemical composition.

The use of Ampco in bushings, gears, acid-resistance service and dies is discussed, while other topics include centrifugal casting, welding rod, forging and machining. One table covers the uses of Ampco Metal by grades.

The book has been streamlined to 24 pages, letterhead size, for convenient filing. Engineers and metallurgists who are interested in aluminum bronze are invited to write for copies of Ampco Metal Catalog 22.

WELDING BOOKS

Books on welding now come near the top in circulation, even in some cases preempting "best sellers," in libraries throughout the country. This is revealed in a report from the American Library Association, with headquarters in Chicago. And at the same time, public libraries, particularly in large industrial areas, are increasing their stocks of books on welding and other technical subjects, far beyond any previous totals. This is the library's contribution to the defense program.

With the beginning of the industrial defense program, public libraries felt an upsurge of demand for technical books, with welding one of the subjects in greatest demand. These requests came from workmen on the job, from engineers and scientists, and from plant executives and department heads. In response to this demand during the past year prepared a number of short buying lists to help them in their selection of books for quick purchase. These buying lists, compiled by authorities in their respective fields were financed by a grant from the Carnegie Corporation and are regarded as a distinct contribution to the defense program since they present the first compilation of all current printed material on vital subjects, including books, text-books, manuals, pamphlets, periodicals and catalogues.

A large portion of the largest bibliography entitled "Industrial Training for National Defense" and compiled with the average workman in mind, is devoted to the listing of books on welding. The same is true of the list entitled "The Shop's Library" prepared especially for school shops, drafting rooms and laboratories. The bibliography on "Shipbuilding and Marine Engines" also contains a special section on welding.

G-E WELDING SPECIALIST

O. J. Pearre has been named arc-welding specialist in the General Electric Philadelphia district office, according to an announcement by W. J. Dorworth, manager of the Philadelphia Industrial Department. Mr. Pearre succeeds W. A. Terry, recently transferred to general sales work.

A native of Baltimore, Maryland, Mr. Pearre was graduated from Lehigh University in 1931 with a Bachelor of Science degree in Mechanical Engineering. At that time he entered the General Electric Company on its test course, later being transferred to Philadelphia to work with S. S. Fretz, G-E's Philadelphia air conditioning distributor.

In his new capacity, Mr. Pearre will have charge of G-E electric-welding sales along the Atlantic seaboard, including the heavy industrial centers of Philadelphia, Norfolk and Pittsburgh. In this area, electric welding has rapidly assumed a new importance because of the use of this means of fabrication in shipbuilding yards and ordnance plants.

Mr. Pearre was engaged in welding application engineering work at Schenectady before being transferred to the Philadelphia district office in September.

THE NEW ENCYCLOPEDIA OF MACHINE SHOP PRACTICE

A guide to the principles and practice of machine shop procedure edited by George W. Barnwell, Professor of Production Practice, Stevens Institute of Technology. This book has a chapter on fundamentals of welding. Price: cloth, $1.98; thumb-notch indexed, du Pont water-resistant binding, $2.48. Wm. H. Wise & Co., New York City, publishers.

WELDING PROTECTION

"Welding Protection" is the title of a new folder just issued by the Safety Clothing and Equipment Co. Cleveland, Ohio. It contains a complete listing of welding protective clothing and devices available.

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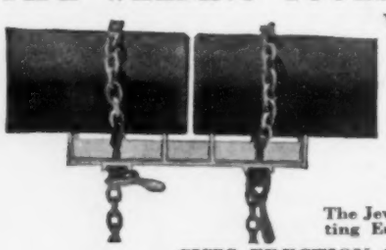

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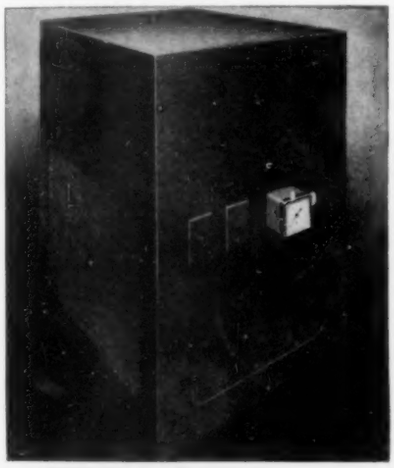
ICE-COLD WELDING NOW POSSIBLE

Speed Welding of Aluminum for Defense Products

DETROIT.—Even faster production-welding of aluminum than already made possible by Progressive Welder Company's 3-Phase aluminum welder is now forecast as the result of the adaptation of "refrigeration" to this machine. Continuous runs without point cleaning for 10 minutes at 100 welds a minute are no longer unusual as the result of the new development, compared with the usual 40 or 50 spots between point dressings.



Progressive Makes New Units Generally Available

DETROIT.—In view of their potential importance in defense production, Progressive Welder Company has announced that its new refrigerating units will not be limited to use with Progressive welding equipment but may be used with other makes of welding machines and for other materials besides aluminum.

Installation is said to be extremely simple since the units are self-contained and need merely be coupled to the normal cooling water connections of the electrodes.

The units are available in a range of sizes permitting the use of one unit to serve as many as four welding machines, if desired.

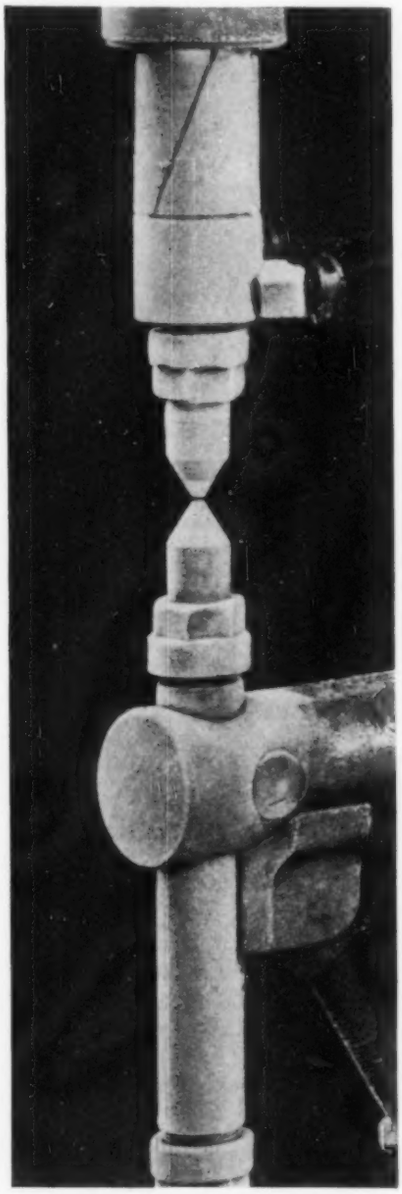
Refrigerating Units to Be Patented

DETROIT.—Patent applications have been filed by Progressive Welder Company on its new refrigerating unit for welders.

Refrigerating Units for Welders Announced

DETROIT.—Welding, at tip temperatures so low that electrodes are continuously covered with frost is the newest and "hottest" thing in welding, particularly the welding of aluminum.

Developed by Progressive Welder Company, of 3050 E. Outer Drive, the new units are said to make possible the welding of four to ten times as many consecutive spots without necessity of shutting the machine down for "dressing" the points.



Unretouched photo of tips taken immediately after a welding run.

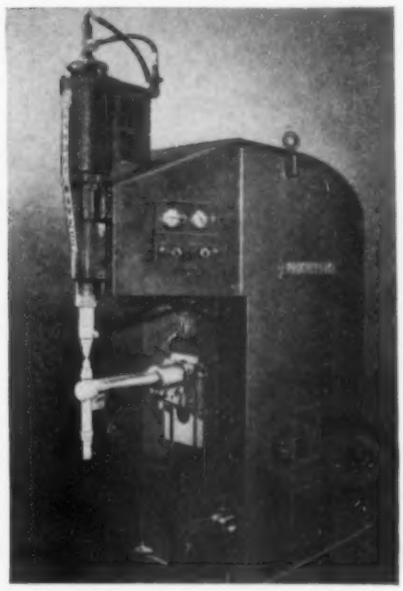
Complete Information Offered

DETROIT.—Complete information on the new refrigerating units will be supplied on inquiry from:

PROGRESSIVE WELDER CO.
3050 E. Outer Drive, Detroit

In spite of the high temperatures required to perform the actual weld itself, electrodes are covered with frost almost to the very tip—even when welding aluminum at 100 welds a minute with the Progressive 3-Phase Aluminum Welder.

In operation the frost line moves up and down the electrode from the tip a mere 5/16 of an inch, every time a weld is made at this speed.



Progressive's short wave aluminum welder (refrigerating unit is behind the welder).

Refrigeration Unit Cuts Tip Pick-up

DETROIT.—Development of a commercial refrigeration unit for resistance spot welders is believed here to be the answer to tip "pick-up," especially in welding of aluminum, stainless, etc. The low temperature of the welding electrodes virtually eliminates the cause of tip pick-up, or partial "welding" of the tip to the material being welded.

AERONAUTICAL ENGINEERING INSPECTORS

The constantly increasing activities of the Navy Department call for many inspectors of aeronautical engineering materials. For many months the Civil Service Commission has had open an examination for inspectors covering several branches of aeronautical engineering materials. The announcement has now been reissued to liberalize the provision for using national defense training courses to meet the experience requirements. The positions pay from $1620 to $2600 a year and the maximum age is 65 years.

There is a particular need for junior inspectors of engineering materials. For these positions applicants need only have completed an appropriate defense training course. Acceptable courses include those in Tool Engineering, Gaging and Inspection Methods, Instrument Design, and related courses in materials inspection or in engineering fundamentals and basic principles.

WELDING CABLE

FlexArc welding cable for work leads and electrode holders is described in a new leaflet announced by Westinghouse Electric and Manufacturing Company.

Flexibility, durability and other features are included in the general discussion. The application of electrode-holder cables are described with a note on their construction.

A tabulation gives welding currents of from 50 to 700 amperes and voltage drop per 100 feet for cable sizes of from 3 to 4/0. Use of the table is explained by tracing the procedure involved in solving a typical welding cable-selection problem.

List prices, quantity discounts, delivery and terms are given.

A copy of catalog section 26-630 may be secured from department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

WELTRONIC ISSUES BULLETIN

A technical and reference bulletin (No. S-41), covering its complete line of resistance welder heat-controls, synchronizers, and synchronous timers, as well as its line of power and control units for welding equipment and automatic machinery, has been issued by Weltronic Corporation, 3080 E. Outer Drive, Detroit.

In addition to descriptions of the individual units, the bulletin also contains general technical material dealing with the application of welding controls.

WELDING AND ITS APPLICATION

Welding and Its Application, by Boniface E. Rossi, Director of Welding Division, The Delehanty Institute, New York, is a book that covers completely the various welding and cutting processes, their related phenomena, their techniques, and their general application in industry. All material represents the latest and best current practices and methods in actual use today. The book is the outgrowth of the author's highly successful course at the Delehanty Institute, where he has trained hundreds of students in electric arc welding, and also reflects his wide practical experience in industry as shop engineer and superintendent. 343 pages. Price, $2.50. Published by the McGraw-Hill Book Company, New York City.

HARRIS CALORIFIC COMPANY ESTABLISHES CHICAGO BRANCH

The Harris Calorific Company of Cleveland, Ohio, manufacturers of gas welding and cutting apparatus, have established a direct factory branch at 619 W. Washington Blvd., in the heart of Chicago's machinery district.

H. D. North, Jr.

Mr. Lorn Campbell, President of the company, has announced the appointment of H. D. North, Jr., as Chicago Branch Manager. Mr. North is a graduate of Cornell University where he specialized in Mechanical Engineering. His continuous association with the Harris Calorific Company in various capacities gives him an excellent background for his appointment.

This new branch with its factory-trained personnel will carry a full and complete stock of equipment and parts which will assure prompt and reliable service to all equipment users.

WELDING EQUIPMENT

Equipment and supplies for use in arc welding are described in a new 11-page bulletin announced by the Westinghouse Electric and Manufacturing Company. Illustrations of all items and tabulations giving sizes, order numbers and prices are included.

A copy of catalog section 26-620 may be secured from Department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

AIRCO COMPANIES

A detailed description of the activities of the five companies which comprise Air Reduction Company, Inc., illustrated both with pictures and diagrams and completely describing the methods, the markets and the nature of the business, was made available to all stockholders of the company.

Because Air Reduction Company today has almost two and one-half times as many stockholders as it has employees—although these latter number over 6100—it was felt that the company should explain this and many other important aspects of its business such as that it is a major producer of oxygen, nitrogen, hydrogen, acetylene, calcium carbide, carbon dioxide, helium, neon, arc welding machines and equipment.

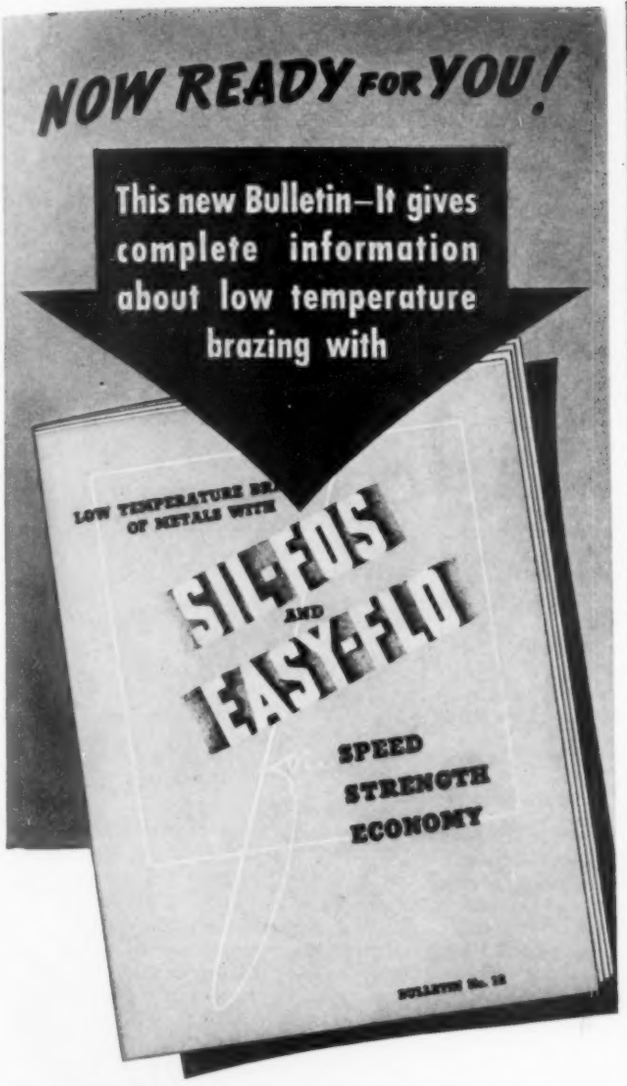
Many of these products are also playing a vital part in numerous industries now in the forefront of national defense—for instance, shipbuilding, aviation, explosives, manufactured gas, sheet metal products and steel works and rolling mills. The trade names under which these products are marketed are often not identified with any of the five Airco operating companies, namely, Air Reduction Sales Company, National Carbide Corporation, Wilson Welder and Metals Co., Inc., Pure Carbonic, Incorporated and The Ohio Chemical & Mfg. Co. Still less are they associated with Air Reduction itself.

The large 54-page book therefore constitutes a major step in acquainting the stockholders and others interested with the true activities of Air Reduction.

BRAD-VERN REPORTS

Detailed information as to how much and where companies have increased their advertising is easy to obtain instantly in the 1941 Annual Book of Brad-Vern's Reports just issued by The Brad-Vern Company, 135–21 Union Turnpike, Flushing, N. Y., and available from them for $12.50.

This Report is a compilation of the schedules of approximately 25,000 advertisers as they are reflected in the 419 publications covered. It represents the second major step in a continuing study begun as of January 1, 1939, for the eventual purpose of indexing all display advertising appearing in all important publications addressed to business and industry. It contains more than twice as much information as the 1940 Report which, in turn, provided more data on such advertising schedules than had ever before been available. With this Report bringing



HERE is timely information of particular value right now to everyone interested in the fast production of strong, reliable joints in ferrous, non-ferrous or dissimilar metals.

Sil-Fos and Easy-Flo brazing has spread in phenomenal fashion throughout industry because these low temperature brazing alloys fill three fundamental metal joining needs—they make **strong, reliable joints, in fast time, at low costs.**

Why they give these important advantages and how you can quickly put them to work in your plant are told in detail in this new bulletin. There are 88 illustrations, mostly of actual applications that alone are full of ideas you may find profitable to adopt.

APPROVED SIL-FOS and EASY-FLO are covered by Army, Navy and other specifications and are being widely used on defense work.

If you have not received a copy of Bulletin No. 12, make sure you get one. Write today. If you have a metal joining problem, send us details and we'll gladly cooperate in finding a practical solution.

HANDY AND HARMAN
HANDY & HARMAN FOUNDED 1867 QUALITY SERVICE
82 Fulton St., New York, N. Y.
Agents in Principal Cities
In Canada: HANDY & HARMAN of Canada, Ltd., Toronto

Improved
with a New Coating

NOW you can get Ampco-Trode, the only coated aluminum bronze welding rod, with an improved coating. The new coated rod makes it easy for the most inexperienced welder to obtain a porous-free deposit by all welding methods. It has much smoother arc action, and the slag is easier to remove.

Made with the properties of Ampco Metal, the rod has high physical properties that make it suitable for tough jobs subject to impact, "squashing out" and wear on sliding surfaces Use Ampco-Trode for overlaying steel and cast iron, building up shafts, wear strips, valve seats, and other parts, refacing for extreme wear-resistance, and building up large forming and drawing dies. It is suitable for metallic arc, carbon arc, and oxy-acetylene welding. Send for literature.

AMPCO METAL, INC.
Department WJ-11 Milwaukee, Wisconsin

Use AMPCO-TRODE
For Any Type of Weld!

Rods from 1/8" to 1/2" in diameter—and in six grades of strength, from 50,000 to 80,000 p. s. i. and hardness from 100 to 375 Brinell—easily used with metallic arc, carbon arc, or oxy-acetylene processes, on steel, cast iron, brass, bronze, and nickel alloys.

WRITE for COMPLETE INFORMATION
Ask for a new bulletin, giving full details of physical properties and applications of AMPCO-TRODE. Our engineers are at your service.

AMPCO-TRODE
A product of
AMPCO METAL
The Metal Without An Equal
AMPCO

the study up to June 30, 1941, the information spans two and one-half years.

Brad-Vern's Reports are issued annually during the list-making and space-buying season. The 1940 Report spanned 18 months to June 30, 1940. The 1941 Report includes this period in total and also the subsequent twelve months.

HUGE TRANSMISSION CASES

A transmission case so large and so heavy that casting it would prove impractical is being successfully built by arc-welded construction for Le Tourneau's huge tournapull machines. Mr. Fred Brown, of the Le Tourneau company, says that a cast transmission case of the same size would cost well over $700 more than the production cost of constructing these cases by arc welding.

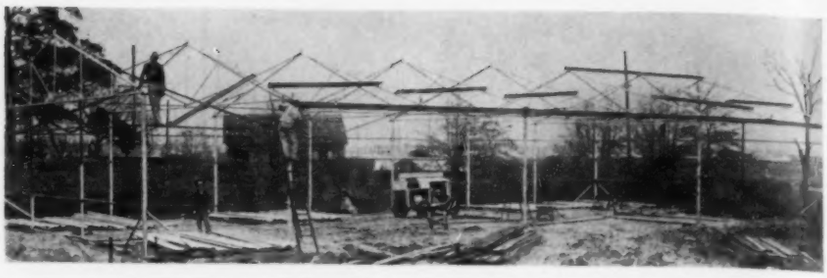
The majority of the parts for the case are machine cut from mild steel. Parts to be bent are then placed in a furnace and heated to a high temperature. The heated parts are then carried by crane to a huge bending machine where the heated parts are placed in a special jig and bent. Other parts to be shaped are heated to a white heat and placed in a die and pressed to shape by a six-million-pound press.

Photographs, by courtesy Hobart Brothers Co., Troy, Ohio, illustrate the magnitude of these mighty machines. This transmission case is being built for a Twin Motor Tournapull.

Parts for the transmission case are then sent through inspection and carried by crane to a jig to be set up. The first welding operation is to heavily tack weld all the parts. Case is then turned in the jig so that all welds may be performed in down-hand position. No welds are completed until every part has a small bead placed on it by skipping around to all parts of the case in order to cut all strains and stresses to a minimum. After the case is completely arc welded it is placed in a large furnace where it is annealed to relieve all locked up stresses and strains. From the annealing furnace the transmission case is conveyed to the machine shop for machining.

USED PIPE IN BUILDING CONSTRUCTION

In consideration of the acute shortage of building materials, it is wise for contractors to remember a multitude of materials and methods for economical construction. For instance, consider the West's popular practice of constructing buildings from used pipe and covering the framework with corrugated metal. When these buildings are constructed by arc welding, the cost is much lower than other materials and methods of construction.



A savings of over $4000 was enjoyed by the Southern Warehouse Company of Houston, Texas when they constructed a 400 × 100 foot building from used pipe.

Trusses and pipe columns were fabricated in a welding shop in ten days time by five welders and one helper. Frame work was erected in one week by two welders, a helper, and a driver operating a Ford winch gin pole truck.

Cost analysis sent to Hobart Brothers Company, Troy, Ohio by the Beago Welding & Equipment Company of Houston is as follows:

Cost of Erection of Framework for 400 × 100 Foot Building

Cost of used pipe.....	$1100.00
Cost of cutting and forming.	75.00
Cost of winch truck and driver	100.00
Cost of power.....	35.00
Cost of electrodes.....	36.00
Labor costs.....	603.00
Overhead.....	150.00
Total cost of above items...	$2099.00

Construction of a similar size building from riveted angles and "I" beams costs over $7000.

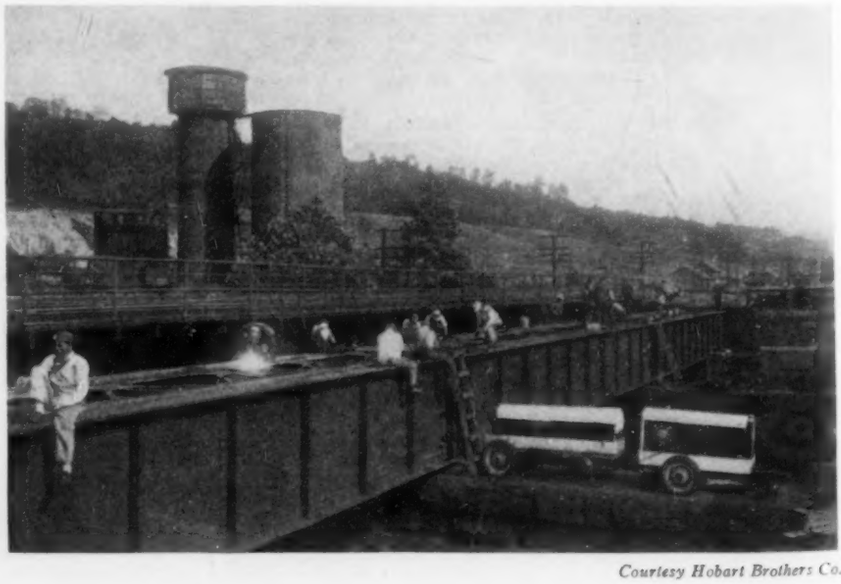
STRENGTHENING BRIDGES

Arc welding was used almost exclusively in the rebuilding and strengthening of two railroad bridges near New Castle, Pennsylvania, and was performed in the record-breaking time of three weeks for both structures.

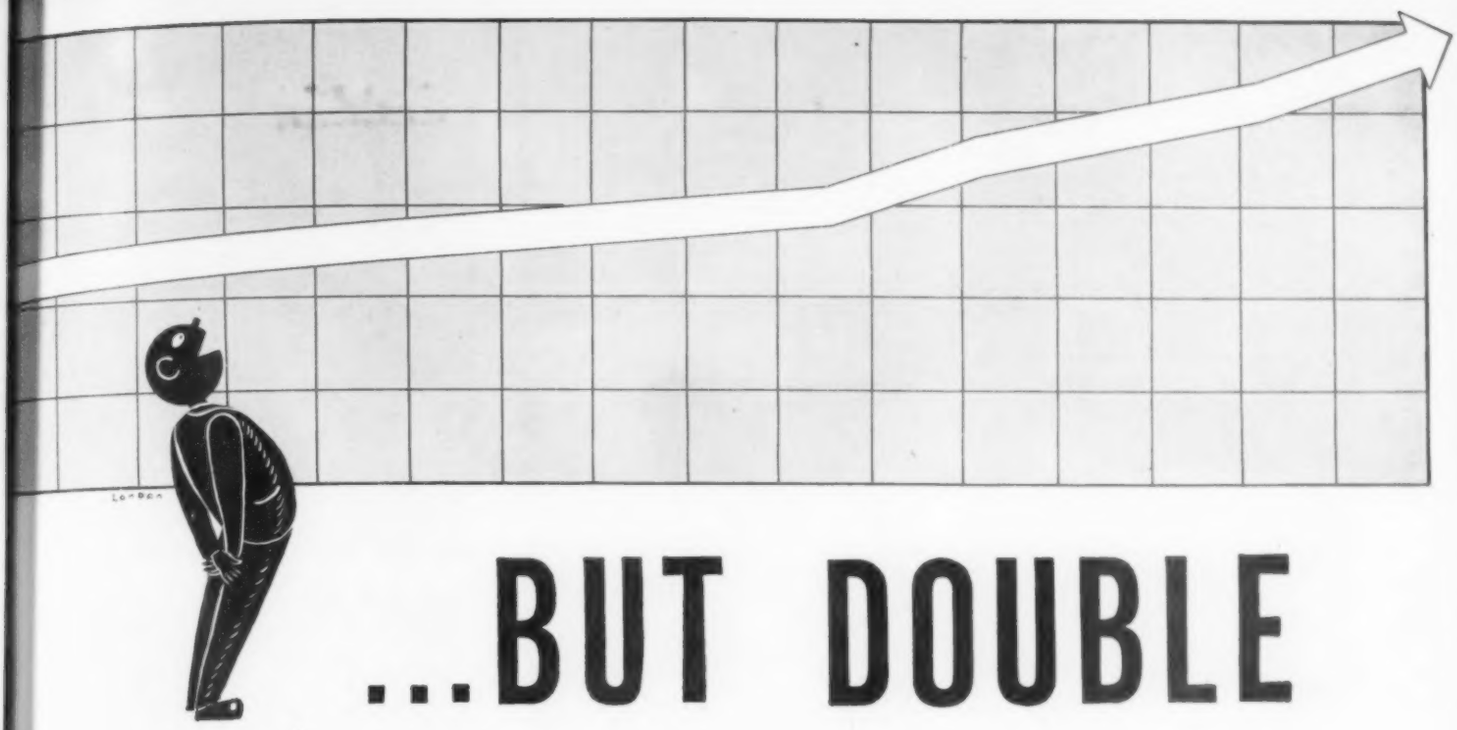
When rust and old paint were removed from top of the steel girders preparatory to welding, an unusual condition for the original rivets was discovered. Rivets were found to be in good condition—with exception of the top heads which were almost entirely rusted away.

The contractor decided that new heads of weld metal could be laid right on the old rivets—making them practically as good as the originals and saving approximately 80% of the renewal cost. This estimate does not include the huge expense that would have evolved from extracting the old rivets and driving new ones.

A bead of weld metal was first deposited around the extended part of the rivet to join the top plate to the rivet itself. Then additional layers of weld metal were deposited in shape of the old rivet head. Top of the girder was constructed from four $^5/_8$-inch plates riveted to an I-beam. First bead of weld metal joining the top plate and the rivet had a tendency to tighten it. Then the additional beads formed the new heads. One man could build up an average of 25 to 35 rivet heads per hour, using $^3/_{16}$-inch coated, straight polarity welding rod.



Courtesy Hobart Brothers Co.



...BUT DOUBLE

is not enough!

Doubling production—or even tripling or quadrupling it—is getting to be an old story these days. As the pace of industry quickens, responding loyally to the urgency of the national crisis, all previous estimates of the country's producing capacity will probably go by the board.

Electrode production, for instance, is now approximately twice that of 1940. By 1942 it will be increased substantially again.

Electrode manufacturers are taking steps so that no user will be embarrassed by electrode shortages. But during this "make ready" stage buyers will be more certain of always having electrodes on hand if they order electrodes when they order steel.

In the meantime, Murex engineers are at your service—to help speed fabrication of welded products and cut costs.

METAL & THERMIT CORPORATION • 120 BROADWAY, NEW YORK
ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

MUREX HEAVY COATED ELECTRODES

THERMIT WELDING — STANDARD FOR 40 YEARS FOR WELDING RAILS AND HEAVY EQUIPMENT

ARC WELDING IN SHIP CONSTRUCTION

Accompanying illustrations, supplied by The Lincoln Electric Company, Cleveland, Ohio, show shipbuilding facilities and work underway on C-1 type cargo ships of the U. S. Maritime Commission at the yard of the Seattle-Tacoma Shipbuilding Corporation, Tacoma, Washington.

The uncovered ways, mold loft (at left) and the steel assembly shop (top center) can be seen in Fig. 1. The main deck of the vessel illustrated is in place and the super-structure ready for erection.

Figure 2 is another view of the C-1 type motor-ship under construction. In this illustration details of the hull framing at the stern can be seen together with the arc-welding equipment.

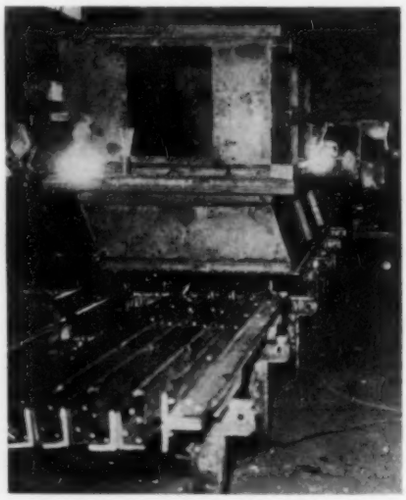
The Seattle-Tacoma yard has been carrying on a program of increasing its facilities and enlarging its plant for the past 1½ years. This is being done to enable construction of C-3 type vessels and other craft such as tankers for the Navy.

The first two ships completed are now in service between the Far East and the Pacific Northwest, a third and fourth have been delivered to the Pacific-Atlantic Steamship Company for service between North and South America. A fifth vessel was just recently delivered to the owner, only 1½ years after the first keel was laid.

CUTTING PRODUCTION COSTS

A 50 per cent sales increase and savings of as much as 40 per cent in over-all production costs and 40 per cent in time are being realized by the Paterson-Leitch Company, Cleveland, through the use of arc welding and in the fabrication of coal hoppers and press brake housings.

Prior to the adoption of welding, riveting was used in the fabrication of coal hoppers. The use of arc welding has also substantially speeded production, as the omission of rivet-heating and hole-punching has cut many minutes from the time previously needed to build a coal hopper, and the product is lighter and better appearing.



Photos courtesy General Electric Co.
Coal Hopper

In addition, the company reports that parts used in the fabrication of press brake housings were formerly cast, and are now completely arc welded eliminating the necessity for drafting, making patterns and casting. More sturdy construction and reduced weight are also obtained, as standard steel plate, cut to correct size can be used with this method of fabrication.

Press Brake

The user states that in his opinion dependability, versatility and low cost of operation are the outstanding attributes of arc welding.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS

The new 7th edition of this Standard Handbook prepared by a staff of specialists is now available. Published by McGraw-Hill Book Co., New York. Price $8.00. Archer E. Knowlton, Editor-in-Chief. This book contains more than 2300 pages on every phase of electrical engineering.

Fig. 1

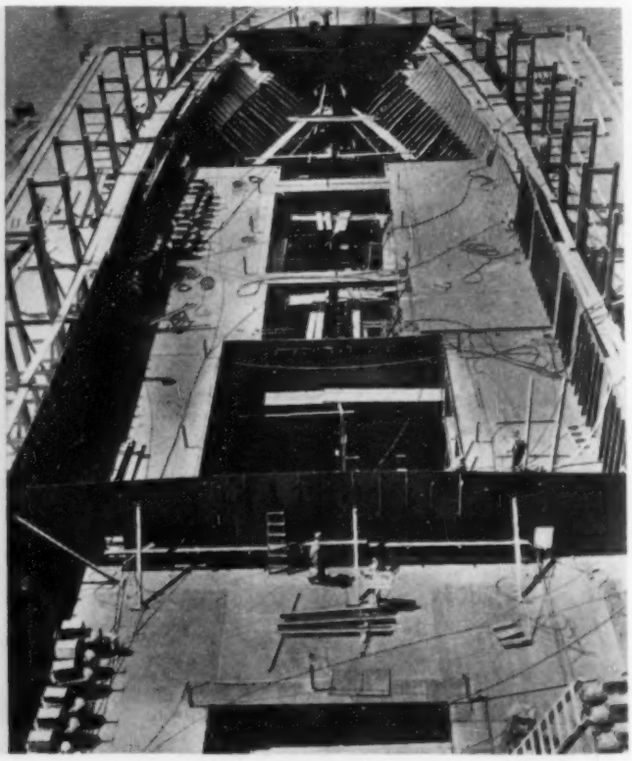


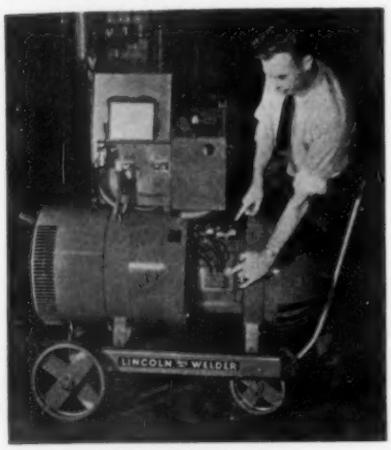
Fig. 2

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

CONTROL DEVICE PROTECTS WELDING SETS AGAINST BURN-OUT

Complete protection against heat or excessive current, or both, is provided by a new protective control device for arc welding machines just announced by The Lincoln Electric Company, Cleveland, Ohio.



The protective control device (see accompanying illustration) consists of two current transformers (upper devices in illustration) the primaries of which are connected in series with the motor leads and the secondaries supplying power to operate two snap-action thermostats which are mounted directly on the motor lamination (lower device in illustration). These thermostats are connected to the lamination in such a way that they operate by means of heat conduction as well as by current passing through the thermostat.

The thermostats automatically reset when the motor returns to a safe operating temperature or when the current is reduced, and no manual operation is required to start the machine, except pushing the start button.

TWO NEW ELECTRODES

Two new types of welding electrodes called Harmomang A and Harmomang B, which have just been announced by the Harnischfeger Corporation, are ideally suited for building up and reinforcing 11–14% manganese steel or carbon steels where high resistance to impact and abrasion is desired.

Type A is a coated manganese-molybdenum electrode on which the thin coating acts as an arc stabilizer and affords protection against loss of manganese and molybdenum. Type B is a bare manganese-molybdenum electrode providing an austenitic deposit.

Both of these Harmomang electrodes are suggested on such work as building up dipper lips and runners, hammer-mill parts, dredge-pump shells, rock-crusher parts, railway frogs, road-grading and mining equipment, etc.

Complete information on physical properties, applications and procedures may be had upon request to the Harnischfeger Corporation, 4513 W. National Avenue, Milwaukee, Wis.

ALUMINUM AND STAINLESS STEEL WELDERS

Designed to increase productivity of resistance welding equipment in welding of aluminum and stainless steel, a line of refrigerating units for welding machines is announced by Progressive Welder Company, Detroit.

While intended to still further increase the productivity of Progressive aluminum and stainless steel welding machines, the refrigerating units (patents applied for) are available for other makes of welding machines in view of their potential importance in Defense for speeding and improving the welding of aircraft assemblies, etc.

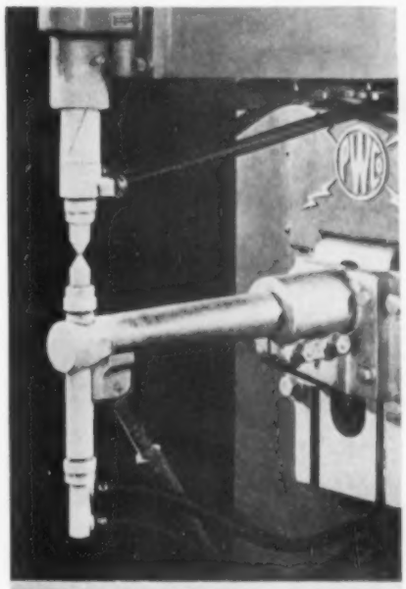
Believed to be the first time "Refrigerated Welding" has been made commercially available, the unit makes possible continuous welding of four to ten times as many spots in aluminum without requiring point dressing.

When used in combination with a spot welding machine, the unit reduces electrode temperature to a point where—in spite of the high heat necessary to produce a weld—electrodes will be continuously covered with frost. This reduction in temperature has so increased point life that 10 minute runs, continuously, at 100 welds per minute without point dressing are not unusual for the combination of Progressive three-phase aluminum welder and the new refrigerating unit.

Primary function of the refrigeration is to keep the welding point cool at the point of contact. In resistance welding heat is generated at three primary resistance points, these being: (1) at the point of contact between the pieces being welded together, (2) at the point of contact between the "upper" piece and upper electrode, and (3) between the "lower" piece and the lower electrode.

Only the first of course is desirable, the other two tending to soften and permit deformation of the electrode tip—also producing pick-up, by alloying of the tip with the material being welded.

Fig. 1—Welding at Sub-Freezing Temperatures!



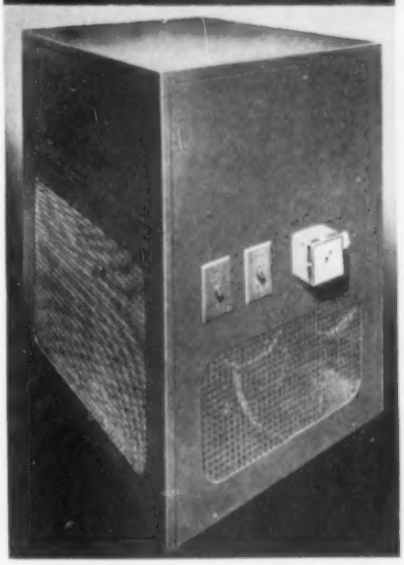
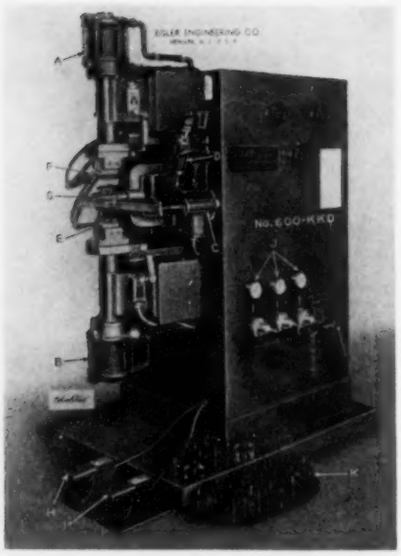


Fig. 2—The New Line of Progressive Welder Refrigerating Units

Installation of the refrigerating unit is quite simple. Being self-contained, it is necessary in most cases only to disconnect the water-lines to the electrodes and couple the refrigerator unit inlet and outlet connections to the electrode water piping.

AIR-OPERATED PROJECTION WELDER

The Eisler Engineering Company, Inc., of Newark, New Jersey has recently placed on the market a special Air-Operated Projection Spot Welding machine No. 600-KKD. This machine is arranged with special welding jigs and fixtures for welding fins to steel tubing. No individual jig is needed for loading the work. There are 56 points of heat control and the Transformer secondary, welding dies and mandrel are water cooled throughout.



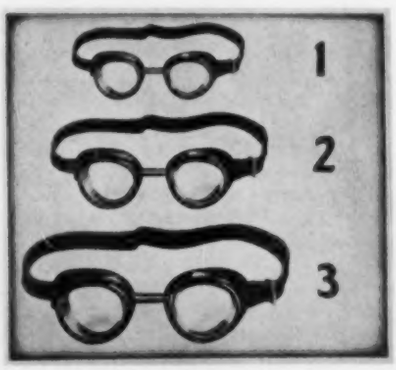
The rotating mandrel is operated by air and fully automatically controlled. The attached photograph is marked to point out the main features as follows: (*A*) Air cylinder for upper welding die; (*B*) Air cylinder for lower welding die; (*C*) air cylinder for the ejector mechanism; (*D*) air cylinder for indexing the rotating mandrel; (*E*) lower welding die; (*F*) upper welding die; (*G*) mandrel; (*H*) foot pedal for actuating ejecting mechanism; (*I*) foot pedal for actuating cylinders *A* and *B*; (*J*) pressure gages—for *A* and *B* cylinders, *C* cylinder and *D* cylinder; (*K*) finished product.

The pressure for each set of air cylinders can be regulated individually to meet any specific requirement. The machine is so wired that the ejector mechanism cannot operate while the welding dies are in motion, nor will the welding dies operate while the ejector mechanism is in motion. The actual welding time is controlled by automatic timing equipment.

Three separate fins are spot welded to each steel tube. Production is approximately 200 finished pieces per hour.

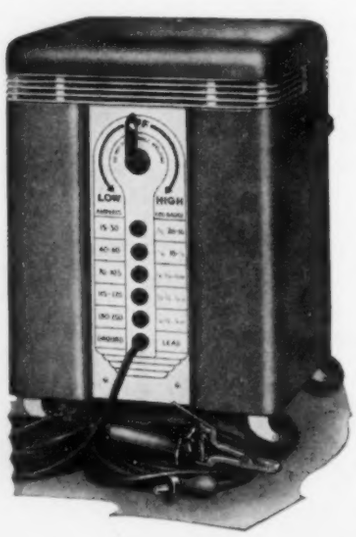
SAFETY GOGGLES

"Face-Fitt" is the name of a new line of safety goggles recently announced by Kimball Safety Products Company. For the first time, according to the manufacturer, a line of composition-frame goggles is available in three sizes (42 x 45, 45 x 48 and 48 x 51 mm.). All are drop-eye shape, which suits the contour of the eye socket better than round lenses and is especially adapted to workmen's use. Extraordinary comfort is claimed for them by the maker. "Face-Fitt" goggles are light weight and ventilated top and bottom with more than 700 holes as contrasted with the minimum of 265 holes required by government standards. Made by Kimball Safety Products Company, 7314 Wade Park Avenue, Cleveland, Ohio.



WELDING TRANSFORMER

This is a new a-c arc welder suitable for all types of industrial services. It is designed to give, in 30 different steps, practically any welding current required between 15 and 250 amperes. The low-heat ranges make it possible to weld very light gauge metal without danger of burning holes, while the high heats permit the welding of heavy parts. Thus here is a general utility, all-purpose machine.



Note that the welder is equipped with swivel casters and therefore portable—easy to handle—ready for work in any part of the shop, merely plug in and weld.

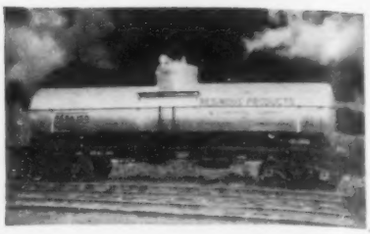
Standard equipment with this unit includes 20 ft. of a-c cable, 20 ft. of ground cable, 20 ft. of electrode cable, and one electrode holder. The price is $154.50.

The manufacturer is Allen Electric & Equipment Company, 1044 N. Pitcher Street, Kalamazoo, Michigan.

STAINLESS-CLAD TANK CAR

What is believed to be the first tank car in which the tank is constructed entirely of welded stainless-clad steel, has just been completed by General American Transportation Corporation at their Sharon, Pa., plant. The tank required 15,000 lb. of "Silver-Ply" stainless-clad steel, supplied by the Jessop Steel Company of Washington, Pa.

Use of "Silver-Ply" in this equipment prevents contamination of the contents of the tank, as the stainless cladding



on the inside of the tank successfully resists the chemical attack which would have taken place had ordinary steel been used.

AUTOMATIC WELDING GUNS

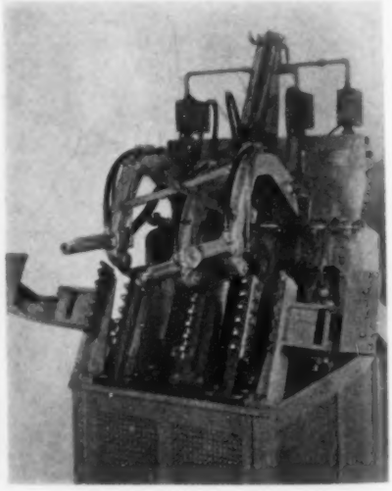
Welding guns that locate themselves automatically for spot-weld assembling of units built up of a number of parts are features of a welding fixture and gun assembly recently developed for the assembly welding of grilles for a low-priced 1942 model automobile.

Built by Progressive Welder Company, 3100 E. Outer Drive, Detroit, the unit is provided with three guns mounted on arms projecting from a slide. (See accompanying photograph.) The operation required the performing of 17 welds in the assembly of the unit. The fixture was so designed that the welds could be performed in groups of three in five different positions of the welding guns, while in a sixth position, only two of the guns are actuated.

This was accomplished by providing the slide carrying the guns with an automatic indexing device. To assemble the grille, it is necessary only to locate the parts in the fixture over the fixed electrodes, clamp them with the two clamps provided at left and right of the fixture, and press a button.

The slide then moves down to the first position, the points of the guns move in against the work, and the weld cycle is started automatically. The points then move out, and the slide carries the guns to the next welding position. The same cycle is gone through, and the slide moves the guns to a third position.

After all welds have been completed,



the slide moves the guns to the starting position and stops, permitting the removal of the assembled grilles and inserting a new set of parts for assembly welding.

With two such welding fixtures it is possible for one to be loaded while the other is going through its assembly welding cycle. The guns are of standard Progressive hydraulic design, while the contacts are of the stationary roller type.

OXYACETYLENE TUBE-WELDING MACHINE

Tubing can now be continuously welded from low-carbon, stainless and other alloy steel skelp at exceptionally high production speeds with a new automatic oxyacetylene tube-welding machine. This machine contains many new features which result in lowered operating costs. It was developed by The Yoder Company, Cleveland, in collaboration with The Linde Air Products Company, New York.

Oxyacetylene welding provides a high-speed method of welding stainless steel tubing with uniformly good quality welds. Now with this new machine it becomes possible to produce high-quality, continuously welded stainless steel tubing at low production cost. The gas welding method is also unique in that it can successfully produce tubing from unpickled, hot-rolled stock for which there is considerable demand in the manufacture of low-cost items such as automotive exhaust tubing, conduit tubing, and structural tubing on which a smooth, polished finish is not necessary.

Table of Operating Speeds New Automatic Oxyacetylene Tube-Welding Machine

Wall Thickness B.w.g.	Speed Range, Ft. per Min.
14	30–100
16	40–140
18	60–150
20	100*

*NOTE: This value limited by mechanical facilities for controlling the lightweight skelp.

The welding table section of the machine contains several new features which make possible the high speed of welding. Heat is supplied from a new type multiple-flame Oxweld duplex welding head which requires 25 to 30 per cent less acetylene per foot of weld, and 5 to 10 per cent less oxygen per foot of weld than welding heads previously used. Separate oxyacetylene supply lines are provided for the welding and for the preheat flames. The supply of these gases is automatically controlled through new-type regulators which are extremely sensitive and provide steady working gas pressures. Regulator adjustments are made at a conveniently located control panel. Provision is also made at the panel for push-button control of the welding blowpipe and the drive mechanism of the machine.

CAPACITOR-DISCHARGE CONTROL FOR RESISTANCE WELDING

A new capacitor-discharge control specially designed for use with stored-energy type resistance-welding machines has been announced by the General Electric Company, Schenectady, N. Y. Stored-energy resistance welding is especially suitable for welding low-resistance alloys, such as aluminum used in aircraft fabrication.

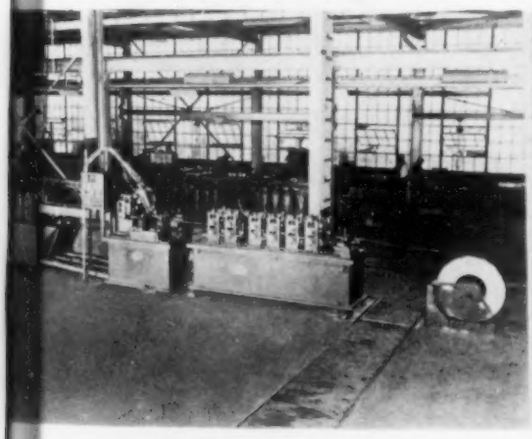
In the capacitor-discharge method of resistance welding, electric energy is stored in the capacitors of the control by a charging circuit, and then rapidly released into the welding transformer, the resulting current producing the weld. The charging circuit then recharges the capacitors, and the operation is repeated.

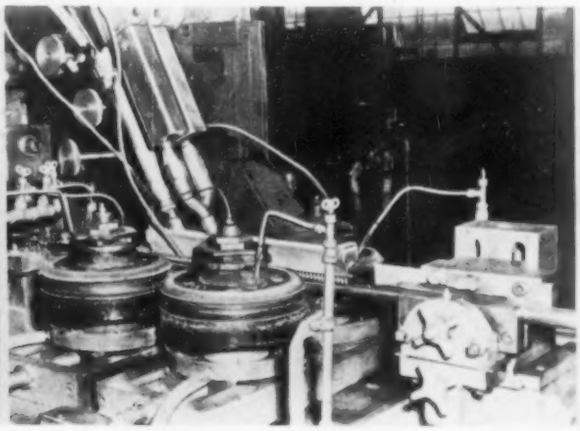
The control cabinet contains up to 22 capacitors, any number of which can be used at one time. Two special tap

Fig. 1—Flat Steel Skelp Is Fed Into This Machine, Automatically Formed Into Tubing and Oxyacetylene Welded at Exceptionally High Speeds

Fig. 2—The Tubing Is Welded by a Combination of Intense Heat from a Multi-Flame Welding Head and Pressure Exerted by Four Guide Rolls

Fig. 3—Oxygen and Acetylene Supply, and the Operation of the Blowpipe and Drive Motor Are All Controlled at a Central Panel





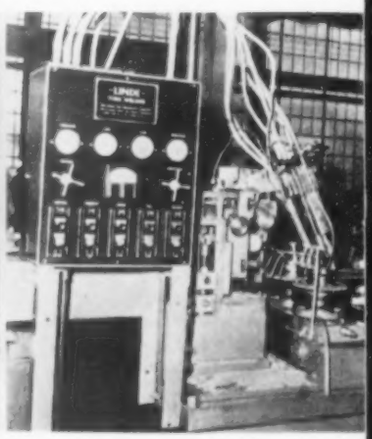
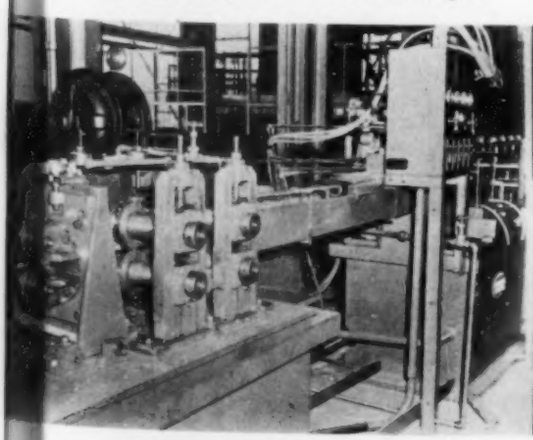
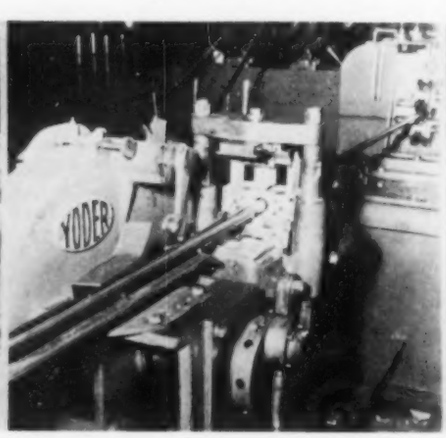


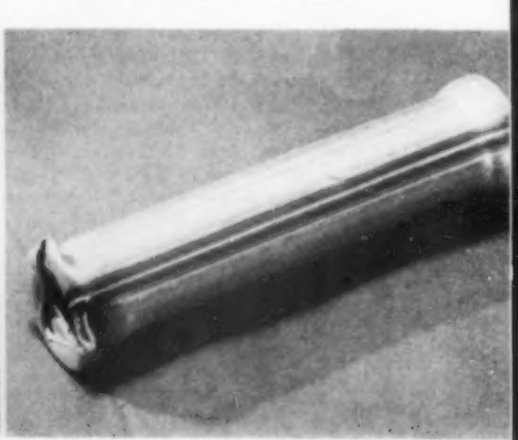
Fig. 4—After It Is Welded, the Tubing Passes Through a Water Quench Trough and Then Through a Set of Rollers Which Straighten the Tubing Before It Is Cut Into Lengths

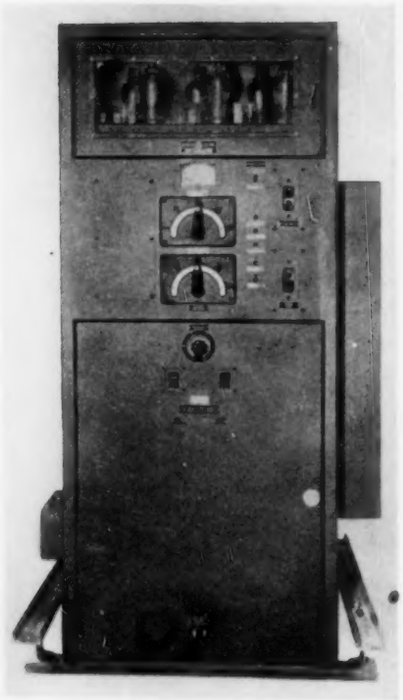
Fig. 5—The Welded Tubing, Cooled and Straightened, Is Cut Into the Desired Lengths by Means of This Automatically Operated Shear

Fig. 6—Note That the Weld Withstood the Crushing at One End and the Diameter Expansion at the Other End Without Failure. The Reinforcement on the Inside of the Tubing Is Less Than on the Outside









switches select the number of capacitors desired in one-unit steps, each of 120 microfarads. By adjusting the voltage output of the control, and by selecting the number of capacitors, flexibility in welding is assured.

A special circuit which prevents operation of the welding machine if the capacitor voltage is less than 3 per cent of its preselected value reduces the possibility of insufficient energy to produce good welds. The charging circuit quickly and automatically charges the capacitors, to the preselected voltage regardless of the number used, thus allowing fast welding speed.

The control is contained in a compact steel floor-mounted enclosing case, 8 feet 8 inches high (over-all), 4 feet $3^1/_2$ inches wide, and 3 feet $4^1/_4$ inches deep. The front portion of the case is divided into three sections, housing the rectifier tubes and their control equipment, the control dials and voltmeters, and a sequence control panel and voltage adjusting potentiometer.

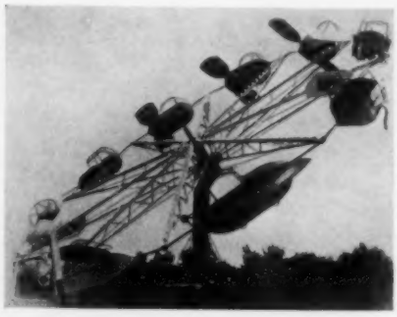
A blower is furnished in the case to resist dust infiltration. Lifting eyes permit the enclosure to be moved by means of a crane, and the bottom is so constructed that the case can be moved by rollers.

SAFETY EQUIPMENT CATALOG

A new 111-page safety equipment catalog has just been published by American Optical Company of Southbridge, Mass., manufacturers for more than a hundred years of products to protect and conserve eyesight. Complete protection from head to ankles is provided by the safety items described which include industrial goggles, Calobar lenses, Super Armorplate lenses, welding lenses, welding plates, welding helmets and hand shields, safety clothing, respirators, first-aid kits, etc. Copies of the new catalog will be mailed free of charge upon request.

ARC WELDED EQUIPMENT FOR THRILL SEEKERS

Contributions of arc welding to "thrill seekers" are indicated in the accompanying photos sent to The Lincoln Electric Co., Cleveland, Ohio, by two welding operators.



Photo, Fig. 1, sent by Elmer Koepke of Maywood, Illinois, shows a carnival ride which is completely welded with the exception of 6 bolts located at center column to permit dismantling for shipping.

Figure 2, photo was supplied by Ed Cusson of Worcester, Mass. It shows tramway chairs built for operation on an aerial ride up Mt. Mansfield in Vermont. Welder Cusson reports that there are 86 of these chairs. The frame work is welded tubing with a seat and arm rest of wood.

WELDING MAKES LIFE EASIER!

Welders are busy men these days and when they get home at night they conserve as much energy as they can when it comes to doing work around the house.

Shown in the accompanying illustration which William A. Van Duyn, Jr. of Enid, Oklahoma, sent to The Lincoln Electric Co., Cleveland, Ohio, is his idea of "another way in which welding is making life easier."

The lawn mowers illustrated are powered with used washing machine motors and are self-propelling. These time savers are 100 per cent welded even to the pulleys on the motor which are made of two steel plates welded to a suitable hub.

Employment Service Bulletin

POSITIONS VACANT

V-104. Technical and practical welding engineer wanted in connection with construction of thirty-six tankers and thirteen cargo vessels under construction.

V-105. Metallurgist wanted. Desire man to take charge Heat Treating Department. Must possess knowledge of metals and hardening of same. Salary $350 a month.

SERVICES AVAILABLE

A-418. Combination welder, also aluminum, 21 years' experience. Wants position as welder foreman. Excellent reference. Married. Work anywhere if steady.

A-419. Experienced welding engineer desires active defense job with plate fabricator, shipyard, or producer of combat tanks. Has specialized in arc welding of all stainless steels, nickel, monel, etc. Has also welded light armor plate to meet government tests. Knows how to handle men and get results. Able to move anywhere.

A-420. Engineer desires position. Graduate Mechanical Engineer 1926. Graduate Westinghouse Welding School. Spent six months in Germany, France, Belgium, England and Switzerland studying welding procedure in use of heavily coated electrodes. Worked as Welding Engineer for R. & H. Chemical Co. in charge of welding department on all metals, ferrous and non-ferrous. Also taught at Trout Vocational School. Have acted for several years as Consulting Engineer. Worked for several years as Welding Engineer for Peter A. Frasse & Co., Ingersoll Steel & Disc Co., and others. Am employed at present but seek a better position.

A-421. Welding Supervisor seeking position in either research or production. Graduate Engineer; experience in fabrication procedures and welding practices on

ferrous and non-ferrous metals; formerly with Navy Department as research welding engineer. Experience in automatic and mechanical welding equipment, gas or electric; X-ray; metallurgy; training and supervision of welders; estimating cost problems; familiar with spot, resistance and Unionmelt welding.

A-422. Research Engineer desires position. Specialist in development of arc-welding electrodes and machines for coating of electrodes. Three years' foreign experience in this line. Graduate Mechanical Engineer. Wants position as production or research engineer.

SECTION ACTIVITIES

BOSTON

The first meeting of the season of this Section was held on October 6th at the Massachusetts Institute of Technology. The speaker at this meeting was Mr. Paul D. Ffield, Materials Engineer, Bethlehem Steel Company, Shipbuilding Division, Fore River Yard, Quincy.

Mr. Ffield gave a very interesting talk on "Some Ship Welding Problems," in which he discussed among other things consideration of locked-up welding stresses, welding sequence, and coordination of activities of welders, "drum-head" welding, and using a combination of castings and welding in producing turbine casings which resulted in a net saving over the use of an all-cast casing.

Included in the many slides he used in his talk, Mr. Ffield showed the application of electric strip heaters for preheating castings in preparation to welding where cracks have occurred. These strip heaters provide constant heat during this repair work.

Attendance at this meeting was over one hundred.

The next meeting is scheduled for November 3rd, also to be held at the Massachusetts Institute of Technology at 7:45 P.M. At this meeting Mr. Mudge and Mr. Spicer of the International Nickel Company are to be the speakers. This meeting will be joint with the American Institute of Mining and Metallurgical Engineers.

CHICAGO

The Chicago Section held its first meeting of the season at the auditorium of the Chicago Lighting Institute in the Civic Opera Building, Friday, September 19, 1941. Dr. W. A. Pearl, Director of Development at the Whiting Corporation and Professor of Mechanical Engineering at the Illinois Institute of Technology, Graduate School, presented an excellent illustrated talk on the subject, "Metallurgical Aspects of Welding." The presentation was well received as evidenced from the lively discussion which followed Dr. Pearl's lecture.

A large turnout for the get-together dinner in the Electric Club and the attendance of over 185 members and guests at the technical session were most gratifying.

A colored motion picture entitled, "Colorado—Vacation Land Supreme," presented by the Rock Island Lines, provided entertainment at the start of the meeting.

CLEVELAND

The Cleveland Section opened its 1941–42 series of meetings on October 8th, with a large and enthusiastic crowd at its new meeting rooms in the Cleveland Engineering Society Building.

Dr. William B. Stout, president and founder of Stout Engineering Laboratories and president of Stout Skycraft Company, spoke on recent developments in welded steel aircraft. Dr. Stout is actively engaged in designing and developing the new "Skycar," a two-place stainless steel plane of welded construction for quantity production.

Major "Jack" Berry, manager of the Cleveland Municipal Airport, talked on "The History and Development of the Cleveland Airport."

CONNECTICUT

The following have been appointed officers of the Connecticut Section for the fiscal year.

Chairman, H. A. Pennington; *Vice-Chairman*, B. H. Perry; *Secretary*, E. S. Elwood; *Treasurer*, J. R. Mitchell.

DETROIT

Mr. G. O. Hoglund, Metallurgist and Welding Engineer, Aluminum Company of America, addressed the October meeting of the Detroit Section held on the 3rd, on the subject, "Welding of Aluminum and Its Alloys." Not only did Mr. Hoglund present all phases of welding and brazing admirably, but he completely satisified the questions of the many automotive-aviation engineers present. There were about 250 present at this meeting.

The December meeting will be held on the 5th. This will be an unusual meeting in that it will be a quiz program—an opportunity to "Stump the Experts." A board of recognized experts will be present to answer questions or problems sent in to the Secretary in advance.

MILWAUKEE

The following officers and directors were elected by the Milwaukee Section for the fiscal year:

Chairman, J. J. Chyle; *Vice-Chairman*, Kieth Walker; *Secretary-Treasurer*, G. F. Meyer. *Directors:* J. B. Welsch, E. C. Brecklbaum, H. F. Wierschem, L. J. Keim, P. Corp, H. E. Bailie and R. E. Boeck.

NORTHERN NEW JERSEY

"The Fabrication of High Pressure Piping" was the subject presented by R. W. Emerson, Welding Engineer, Pittsburgh Piping & Equipment Co., at the October 28th meeting of this Section. Plant and management problems involved in meeting the exacting specifications of modern high-pressure power plant piping installations were discussed.

"Welded Tubular Structures" was the subject discussed by H. S. Card, Director of Product Development, Formed Steel Tube Institute. In this paper, tubes were discussed for their structural values rather than as flow lines. The inherent structural advantages of the tubular section were explained and illustrated by numerous industrial applications.

A movie, "Conquest of the Hudson," was shown through the courtesy of the Port of New York Authority. This was the story of the planning of the Lincoln and Holland Tunnels.

NORTHERN NEW YORK

The following officers and executive committee members were elected for 1941–42:

Chairman, E. F. Potter; *First Vice-Chairman*, M. F. Sayre; *Second Vice-Chairman*, E. F. Spittler; *Secretary-Treasurer* W. W. Churchill. *Executive Committee:* R. A. Gilbert, A. F. Stiglmeier, J. R. Lipsky, R. W. Clark, F. H. Miller, G. G. Somerville.

This Section held its first fall meeting Thursday, September 25th, at the Berkshire Hills Country Club, Pittsfield, Mass. Mr. H. C. Cogan, Chief Engineer, National Electric Welding Machine Co., was the speaker. His subject, "Development in High Production Resistance Welding," was illustrated.

NORTHWEST

The first meeting of the season was held on September 24th at the Coffman Memorial Union, University of Minnesota. Mr. W. Lyle Borst, Chief Engineer, Power Service Corp., spoke on the subject, "Commercial Pipe Welding." This was a timely and important subject, for welded pipes are now carrying tremendous pressures, not only in power plants but in many other applications.

Mr. W. B. Browning, Service Engineer The Linde Air Products Co., was the guest speaker at the October 9th meeting. Mr. Browning spoke on "Shape Cutting, Plate Edge Preparations and Gouging."

The following is a tentative program for the remainder of the season.

Nov. 6th—"The Experimental Background to Welded Design." Speaker—L. C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp.

Dec. 11th—"Procedure Control of Welding and Qualifications of Welding Operators." Speaker—E. W. P. Smith. Con-

sulting Engineer, The Lincoln Electric Co.

Jan. 15th—"Jigs and Fixtures." Speaker —R. W. Sternke, Gen. Supt., Lakeside Bridge & Steel Co.

Feb. 11th—Speaker to be announced.

Mar. 19th—"Welded Steel Structures." Speaker—LaMotte Grover, Structural Welding Engineer, Air Reduction Sales Co.

Apr. 9th—"Metallurgy of Welding." Speaker—E. C. Chapman, Combustion Eng. Co.

May 14th—Annual Meeting and election of officers.

The regular Educational Course will also be held.

OKLAHOMA CITY

The Oklahoma City Section held its first meeting of the 1941–42 season in the Biltmore Hotel, October 9th. Mr. Earl Bouilly of American Airlines presented a sound film, "Flagships of the Air," accompanying his presentation with comments and answers to questions.

Mr. Charles Reed, Superintendent of the Horshoe Lake Station of Oklahoma Gas and Electric, spoke on "Welding in the Operation and Maintenance of Central Power Station Equipment." The third speaker, Mr. Howard Sims, metallurgist for Black, Sivalls & Bryson, gave a short illustrated talk on "Great Refinement in Multi-pass Welds."

Mr. Bill Rice, of Oklahoma A. & M. College, drives 65 miles each way to attend these meetings and is generally accompanied by four or more of his students and two or three of his faculty associates.

PHILADELPHIA

The Program Committee of the Philadelphia Section opened the season with one of the finest meetings in the history of the Section. Mr. E. V. David and Mr. W. Spraragen, Chairman and Secretary, respectively, of the National Program Committee, were guests of the Section at this meeting.

The subject of the meeting, "Stainless Steel Electrodes for Welding Air Hardening Steels," was introduced in a short talk by Mr. Harry W. Pierce, who outlined the problem and showed its relation to work being done by local industrial plants and shipyards. The main speaker, Mr. R. D. Thomas, covered the application of special analysis stainless steels and carefully outlined several reasons why a controlled welding technique is necessary in the use of these steels. Approximately 170 were present at this meeting.

The Membership Committee of this Section is seeking through approximately 40 key men in the welding industry in the District, a list of prospective members. Mailing and follow-up by personal call will then be employed to obtain as many of this list of "members we want" as can be obtained. This effort, directed at specific individuals, it is hoped, will be more effective than just a general call for more members.

PITTSBURGH

The October meeting of the Pittsburgh Section was held on the 15th. Mr. Charles H. Jennings, Research Engineer, Westinghouse Electric and Manufacturing Co., spoke on "Modern Welding Machines." This talk compared the different types of machines from the standpoint of weldability, efficiency and usability.

Mr. Wm. D. Halsey, Assistant Chief Engineer, Boiler Division, The Hartford Steam Boiler Inspection & Insurance Co., will speak on "American Welding Society Standard Qualification Procedure" at the November 19th meeting of this Section.

ST. LOUIS

Mr. W. A. Pearl, Director of Development at the Whiting Corp. and Professor of Mechanical Engineering at Illinois Institute of Technology, presented an interesting lecture on "Metallographic Aspects of Welding Various Alloys" at the October 10th meeting of the St. Louis Section. This lecture was illustrated by an assortment of photomicrographs that covered practically all phases of welding.

SOUTH TEXAS

The South Texas Section held the first meeting of the 1941–42 season on the evening of September 25th, and heard a very interesting discussion on X-ray technique by Mr. T. D. Ketchbaw of the Industrial Welding and Testing Laboratory. Recent new developments in this method of weld examination were pointed out, and Mr. Ketchbaw showed results of recent research in the X-ray of stressed steel.

Mr. Theodore Felds, district manager of the E. D. Bullard Company, was the visiting speaker for the meeting, and gave a most interesting lecture on "The Construction and Effects of Incendiary Bombs in Warfare and Sabotage." Mr. Felds gave several demonstrations to show the effectiveness of incendiary materials, and endeavored to extinguish a thermite fire with water. The damaging properties of sodium metal in water, yellow phosphorus in air, and a mixture of yellow phosphorus and magnesium in air were demonstrated and explained by Mr. Felds. This discussion was somewhat aside from welding, but was very much appreciated because of its current importance.

TULSA

Mr. Robert Lee Looney, District Manager, Lincoln Electric Co., spoke on "The Lining of Towers by Stainless Alloy Steel" at the October 10th meeting of the Tulsa Section. Mr. Looney has had just short of a quarter century of experience in welding from the practical, or field side of the business, and has covered a wide area extending from Old Mexico to Michigan.

WASHINGTON

The first regular meeting of the Washington Section was held on October 2nd, at the auditorium of the Potomac Electric Power Company. As usual, it was preceded by an excellent dinner at the Press Club. Colonel G. F. Jenks, Technical Adviser to the Chief of Ordnance and President of the AMERICAN WELDING SOCIETY, spoke on the subject, "Welding in National Defense."

The speaker has been in close touch with both research in welding and construction of ordnance materiel since the War Department first became interested in this subject about fifteen years ago.

The chief consideration for the construction of mobile materiel is to provide both fire power and mobility. Obsolescence obtains before fatigue failure can occur. Accuracy and permanence of dimensions are extremely important, hence welded structures are stress relieved. Sections $^1/_2$ in. in thickness may be given such treatment for six hours. Radiographic inspection of cast metal was first used in this country at Watertown Arsenal where British techniques were first investigated.

Colonel Jenks cited numerous instances wherein weldments replac d castings with a material saving in weight and a consequent increase in mobility of materiels. A number of slides of modern materiel were shown in which welded construction decreased weight as much as 40% and at the same time did not decrease, and in some instances increased, firing power.

A brief discussion of applications of resistance welding showed how bombs and mortar shells have been improved over the early methods of casting, forging and hot forming. Bombs, though intended to fragment completely, must remain intact upon impact with the earth, hence 100% joint efficiency and considerable ductility are required.

This strength is necessary to prevent low order explosion which occurs if a bomb case bursts upon impact and before the explosive can be detonated. The contradictory properties of high strength, ductility and fragmentation on explosion are successfully met by welded bombs. In lieu of the expensive drop test given to test bombs, the Ordnance Department has developed a hydrostatic test in which the bomb wall is plastically deformed. This test is fool-proof in inspection of welded cases and at the same time gives the bomb a dynamic symmetry. Small surface and subsurface imperfections in the welds are identified by this test.

In conclusion, Colonel Jenks briefly summarized the importance of welding to national defense and solicited questions, the response to which indicated that his audience had been made thoroughly conscious of the welding problems being coped with today.

YORK-CENTRAL PA.

The following officers have been elected for the coming year:

Chairman, W. B. Lair; *Vice-Chairman*, W. E. Hollingshead; *Secretary*, C. E. Lewis Kerchner; *Treasurer*, E. E. Rouscher.